MAY 25 1937

Engineering News-Record

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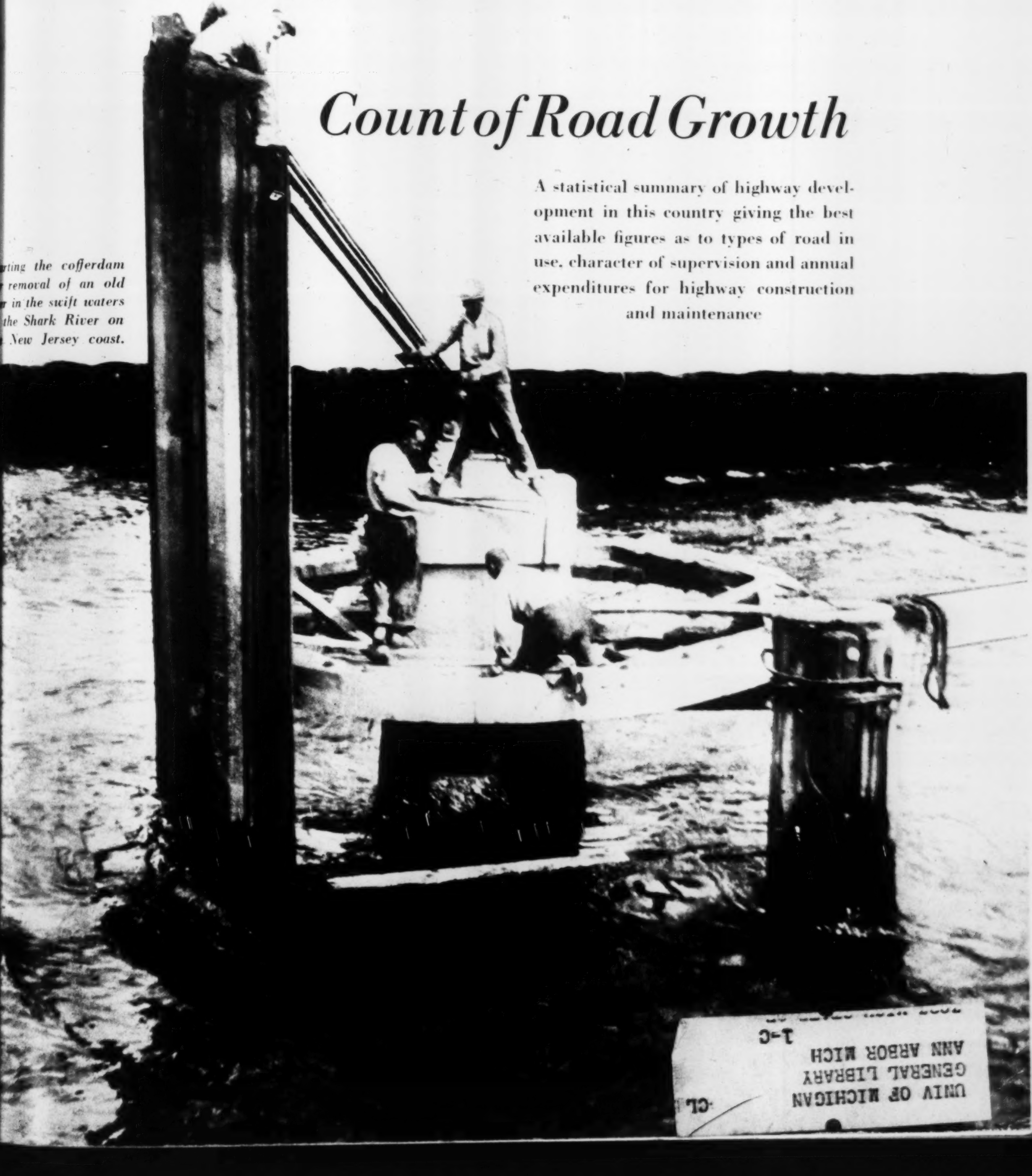

rting the cofferdam
removal of an old
in the swift waters
the Shark River on
New Jersey coast.

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BECAUSE IT OFFERS many economical advantages for replacing, extending or relining small bridges, Armco Multi Plate is gaining widespread popularity among highway engineers and officials.

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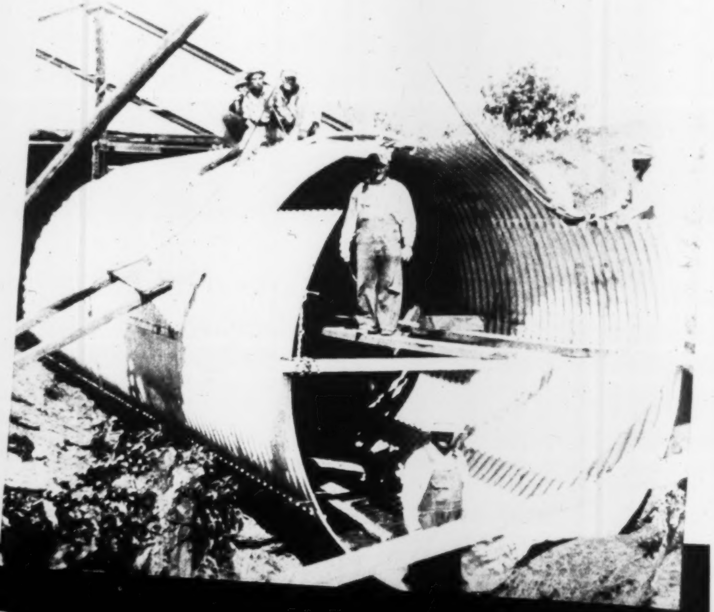

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Above: REPLACING **a truss bridge in Iowa with 50 feet of Armco Multi Plate Pipe, 12½ feet in diameter.**

Below: EXTENDING **a concrete bridge in Indiana with a 15-foot span Multi Plate arch, set on concrete footings.**

ARMCO MULTI PLATE

To *Reequip* the Industry

DURING the last few days two items that have come to the desk of this writer have a bearing on the business both of those who read this journal and of those whose names appear in its advertising pages. And that means a very substantial share of all those who have anything to do with engineering construction.

The first item is culled from the May 6th issue of *The Central Constructor,* that always interesting bulletin of the Central Branch of the Associated General Contractors. It is worth quoting extensively:

"Iowa's 1937 highway program will formally open with the season's first letting on May 11th * * *

"Contractors bidding on this work will, of course, carefully note the requirements of the new specifications, realizing that they cannot operate except by complying with them faithfully, and that they cannot make a profit without performing under them to the satisfaction of the commission.

"Fewer bidders, however, will realize that they are failing to comply with a law which is both economic and natural — the law of obsolescence. Equipment wears out both through the working of the laws of physics — through friction and wear and tear — and through the passage of time — time which has produced something better in the way of a machine that will do the same work quicker or at lower cost, or will do more work in the same time or for the same expense.

One of the large items of cost with which contractors must deal in performance of new work is the obsolescence of their equipment. Too few bidders take this item into account, though standard A.G.C. documents have long been available from which obsolescence can be closely estimated even by the inexperienced.

"There have been radical changes in equipment, especially for grading work, during the past two years. Depreciation and obsolescence have been estimated by some contractors to run as high as 25 per cent of the entire cost of a project. It is an inescapable cost factor — one which cannot be avoided even by discontinuing operations entirely. The man who does not believe this has only to attempt to put into use again a machine which he has stored for a few years, keeping it housed against the weather and well oiled. If any progress at all has been made in the design of the equipment manufactured to do the work for which that particular machine was made five or ten years ago, its owner can no longer afford to employ it on his job. Time has worn it out, even standing still."

THE other item, although not related to this, throws light on the same subject.

A survey, covering hundreds of contractors east of the Mississippi to check on idle equipment, shows that with the exception of but two of the contractors called upon the equipment of everyone is in full use. Much of it is working overtime and must soon be replaced.

The construction industry as a whole is not exempt from the general rule that today, because of the ravages of both deterioration and obsolescence, the American industrial plant must be substantially rebuilt and replaced. If the industry is to carry on with its accustomed efficiency and with due regard to the cost and quality of its product, both constructors and equipment men must recognize the present need to reequip the industry for the work that lies ahead.

Willard Chevalier

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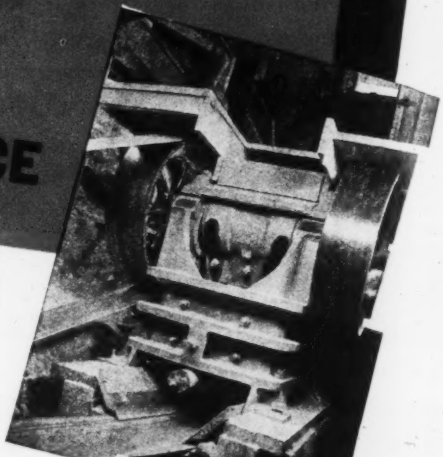

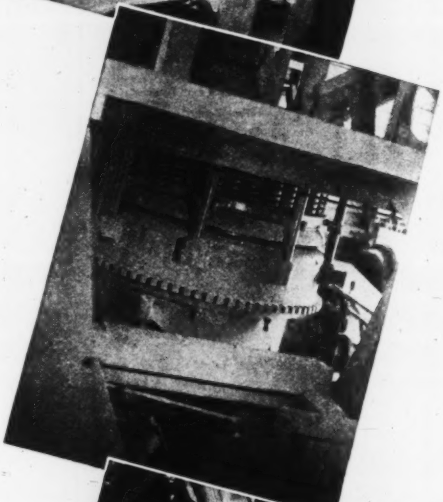

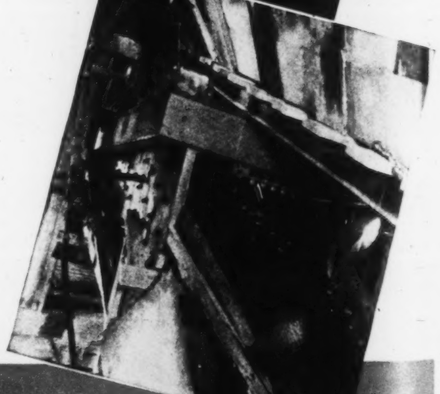

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MAY 20, 1937

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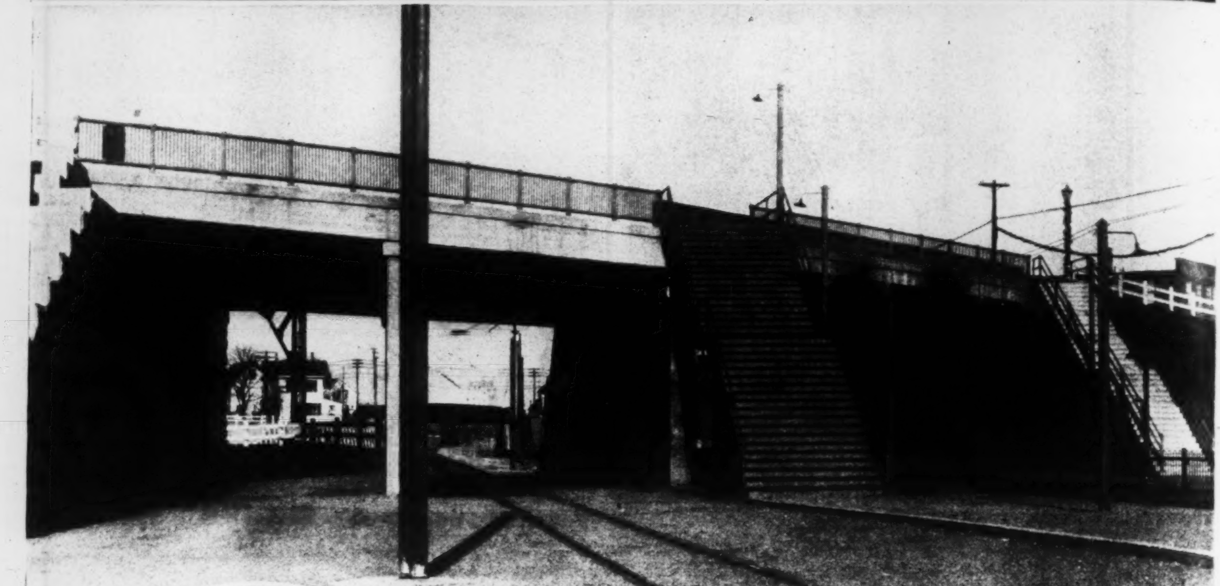
■

Waterworks in every community are being called upon to render wider service in meeting demands for extra quantity and better quality. How well are water systems keyed up to handle these greater tasks and what can be done to improve their performance? Next week's issue will feature eleven articles on operation, maintenance and management that point the way to water system improvement.

Give it a Hand!



These lamp posts on the Triborough Bridge, New York, illustrate one of many uses for Republic Pipe. The light weight, strength, ease of fabrication and economy of a uniform tubular member will suggest other uses.

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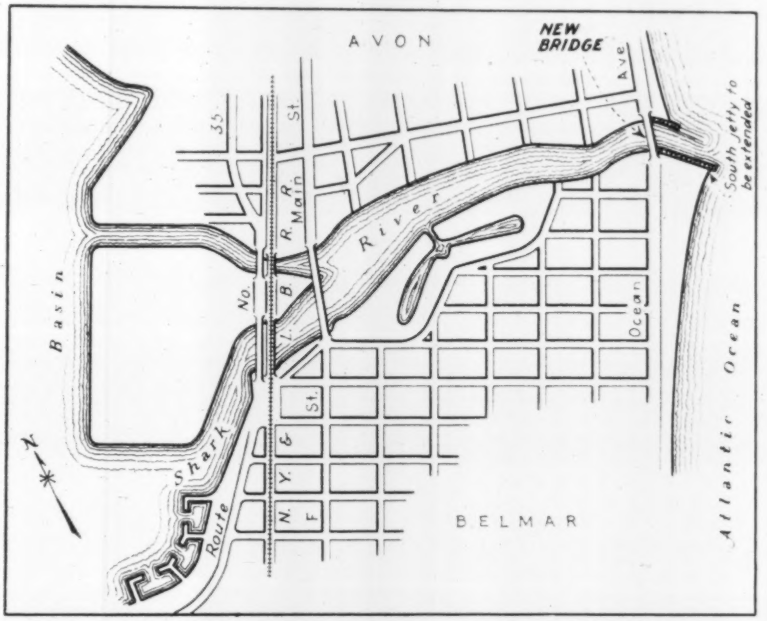


FIG. 1—SHARK RIVER INLET showing the bridges between the New Jersey coast-resort towns of Avon and Belmar.

Cofferdamming Difficulties In a Narrow Tideway

Bridging the mouth of the Shark River on the New Jersey coast called for a resourceful battle with tidal currents, ground swell and old foundation obstructions

By Edwin R. Albertson

Belmar, N. J.

A TIDAL WATER foundation operation that called for a resourceful change of plans and working methods as unexpected conditions were encountered has just been completed in bridging the mouth of Shark River between Avon and Belmar on the New Jersey coast. Among the controlling conditions were a tide range of about 5 ft., a heavy ground swell, something of a tidal bore in the river, 25 to 30 ft. depth of water, and part remains of old pile foundations that had to be revamped, or removed. Cofferdamming the new pier sites under these conditions developed a variety of troubles and of devices to overcome them. This is the story that is told here and it is not pretended that it has more importance than that it tells of ordinary constructors meeting ordinary difficulties and thinking nothing of doing it. This story is not too commonly told.

Shark River, one of the many small streams along the New Jersey coast, flows into the Atlantic between Belmar and Avon. One mile inland the river widens out into a basin, providing a safe harbor for scores of small fishing and pleasure craft (Fig. 1). Between the inlet and the basin the river is spanned by three highway bridges and a railroad trestle. The highway bridges are all of the bascule type and the present railroad structure is being altered and a bascule leaf added. It is planned in this way, to make the harbor attractive to more and larger boats.

The oldest of the three highway bridges, the Ocean Ave. crossing, is located directly at the river's mouth, the sidewalks of the bridge acting as a connecting link between the boardwalks of Belmar and Avon. For various reasons the War Department ordered the Ocean Ave. bridge removed, and a new one is now being erected on the original site.

The new bridge has three spans, supported on two river piers and two abutment piers on shore. The double-leaf bascule span, between the two river piers, provides a 90-ft. clear channel between the fender systems. The footings of the two river piers are about 10 ft. deeper than the old ones, the additional depth being made necessary by the scouring action of the stream, which had lowered the bottom considerably since the orginal bridge was built. The new piers, like the old ones, are carried on timber foundation piles.

The construction plan

The contractor planned orginally to use floating equipment for demolishing the old bridge and constructing the new one. However, it soon became apparent that the ground swell would make this procedure impracticable and it was

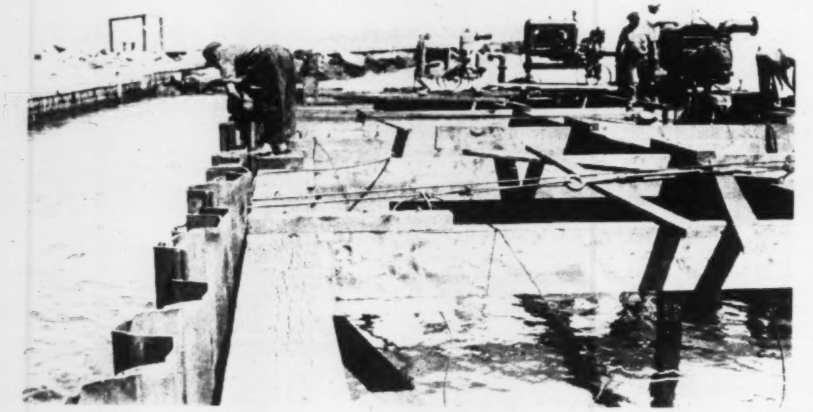


FIG. 2—COFFERDAM for the north pier of Shark River Bridge as the first unwatering was begun to inspect the piles of the old foundation.

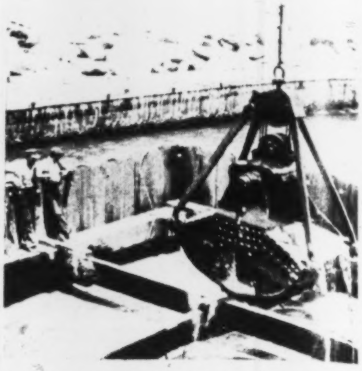


FIG. 3—EXCAVATING the reflooded cofferdam by clamshell operating through the panels between bracing.

abandoned. Moreover, although there is but a 5-ft. tide at this point, the currents in and out of the river's mouth are very swift, which contributed to the decision not to use floating plant.

It was therefore planned to start construction at the north bascule pier, and demolish the old four-span bridge southward from the north abutment. One and a half spans were first removed, together with the old north pier which fell within the area of the new one. The remaining half of the second span was supported at the north end by temporary timber piles, and served as a working platform for part of the equipment. Demolition was carried on by a gasoline crane on the north bank and a 25-ton whirley working from the old bridge. As construction progressed additional sections of the old bridge were removed, the whirley retreating toward the south shore. A second whirley was later assembled on the north shore where it handled the heavy work at this end of the bridge.

Sinking the north cofferdam

A rectangular bracing cage of wales, struts and posts, for the cofferdam of the north bascule pier, was assembled on the south bank. The scouring of the river bottom had undercut the footing of the old pier, so that when it had been dynamited out the pile tops were left protruding above the river bed. When the site had been cleared to this extent the frame was launched from the south bank, where it settled to the bottom of the shallow river. It was then dragged and lifted into position by cables from the whirley, assisted by cranes on the north shore. Steel sheet piling was set up around the frame and partially driven; a special driving head was used with grooves to fit the deep-arch sheet piling.

To unwater the cofferdam and inspect the old piles, five 6- and 8-in. centrifugal pumps were set up around the top tier of bracing. The sheeting was pulled in against the frame by cables and by turnbuckles to tighten the joints and prevent the sheeting from flapping with the ground swells. Soft-coal cinders were poured into the water around the outside of the coffer, to be drawn into the interlocks and stop the leakage of water. The first attempt to unwater was made at high tide and was unsuccessful, as the ground swells kept the sheeting in motion and washed the cinders out of the joints. Another attempt was made at low tide, just as the water was starting to rise, and was entirely successful. At the second attempt there was 5 ft. less depth of water, thereby appreciably cutting down the linear feet of sheeting joints through which the water might flow, as well as reducing the pressure head. As the pumps were now able to hold their own against the infiltration, the rising tide on the outside built up a head of water, and the unbalanced pressure forced the sheeting hard against the cage, closing the interlocks. Leakage through the joints continued to decrease as the head of water built up on the outside.

As soon as the lower wales were exposed, two of the pumps were shifted to this level. Water continued to spurt through the joints, here and there, and it was necessary continually to dump additional cinders around the outside of the sheeting opposite the worst leaks. After the water had been lowered to the desired level one 8-in. pump was able to handle the seepage most of the time, but an additional 6-in pump was kept in place as a stand-by.

Several of the existing piles were then pulled to determine their fitness for further use. The tops of the old oak piles were badly eaten by teredos in the area which had been exposed below the old footing. However, below the ground line they were found to be in perfect condition and as they were probably better than most local timber available at this time it was decided to use them. Three methods were considered: First, the piles might be pulled and later re-driven; second, the cofferdam might be excavated to grade and the piles driven to the new level, and

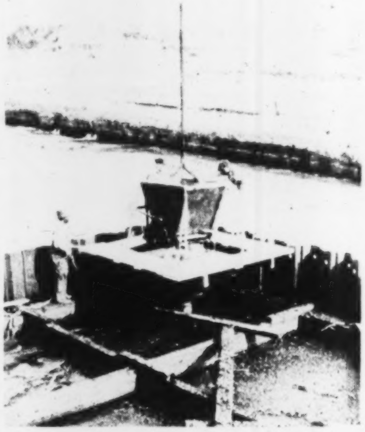


FIG. 4—CONCRETE SEAL being placed in the flooded cofferdam through a pipe tremie.

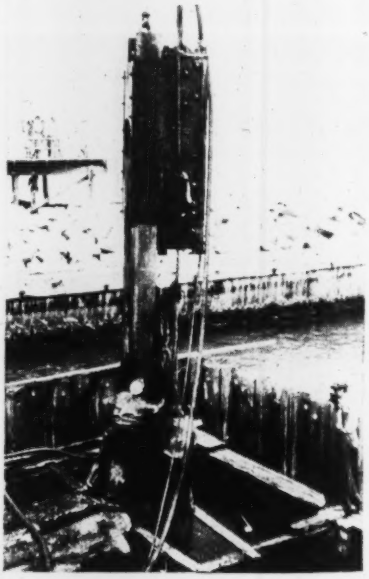


FIG. 5—DRIVING the new foundation piles under water using an I-beam spud to guide the hammer and keep the pile in line.

last, since it was learned that they were fairly long, they might be left undisturbed and cut off to the new grade along with the new piles to be driven.

The material in the river bottom consists of alternate layers of sand and clay, at varying elevations and of varying degrees of hardness. After some consideration it was decided not to pull the piles for fear that the river bottom might blow in, jeopardizing the cofferdam. The ground was excavated around several of the piles and they were then driven 5 or 6 ft. with a steam hammer. The vibration of the soil from the hammer allowed the water pressure to force the steel sheet piling in at the toe, and this method was abandoned. It was decided to leave the piles as they were, at a reduced bearing value, and supplement them with additional new piles. The pumps were then pulled and the cofferdam flooded.

Excavation within the cofferdam was by clamshell bucket through water, to a level 4 ft. below the bottom of the new footing. The excavation was made mostly in the centers of the cofferdam wells and it was necessary to level off the bottom by a water jet, the high spots under the struts and around the walls being washed down into the hollows. The extra 4 ft. of excavation provided for a certain amount of pile swell and a shallow concrete seal. The seal served the double purpose of preventing the bottom from boiling and as bracing for the sheeting at that level.

Driving new piles

The cage was then driven down to its final position, just clear of the pier footing; a steam hammer, driving on a short length of pile set on the top wale over post points, accomplished this step without difficulty. This would not have been the case if the sheeting had not been set plumb, or had the driving of the old piles continued so as to let the toe of the sheeting in. With the frame in place the sheeting was driven to grade, with the top about 5 ft. above mean high tide.

The new piles were driven through water. In place of the customary swinging leads a 24 in. I-beam spud was used, hung from one of the load lines of the whirley. A steel plate yoke attached to the double-acting steam hammer encircled the spud and guided the hammer into position. The spud was first spotted in place for the pile and the hammer, held by a second load line, was raised to the top of the spud to make room for the pile. A third line, operated from the niggerhead on the hoisting engine of the whirley, handled the pile into place in front of the spud, after which the hammer was landed on the head of the pile.

The hammer was rigged for underwater driving, a section of steam hose being fastened to the exhaust and extended to a point above water level. A line coupled to a small portable compressor supplied air at somewhat more than the water pressure to the air inlet on the hammer. Most of the piles required the assistance of a water jet to get them down. The jet consisted of three 20-ft. lengths of 2½-in. pipe coupled together, with a goose-neck bend at the top, and tapered to 1½-in. at the lower end.

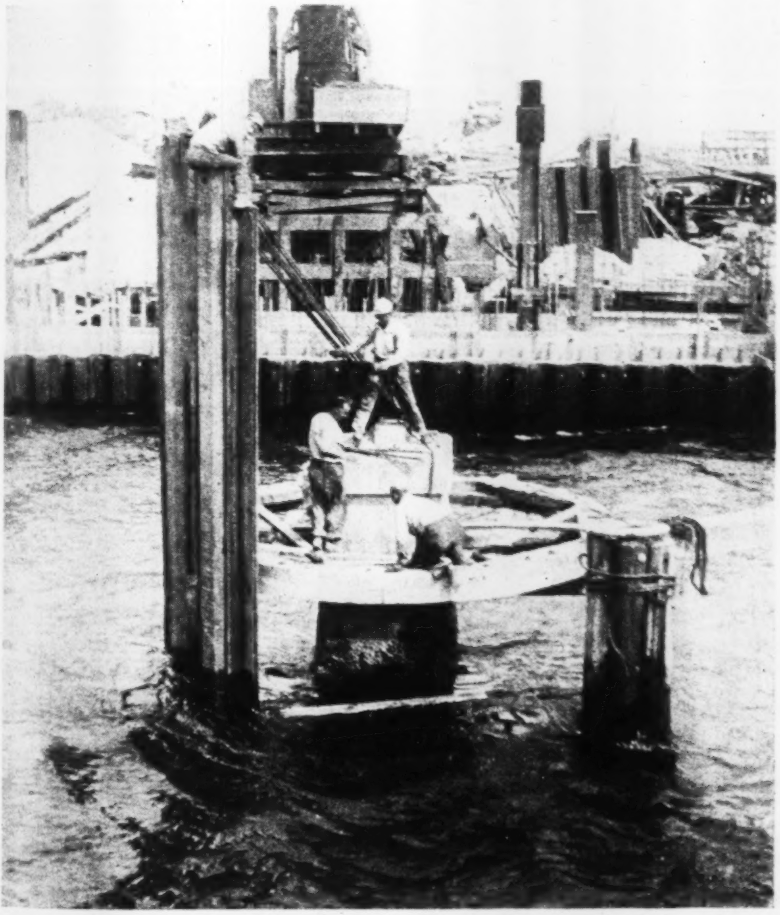


FIG. 6—A CIRCULAR COFFERDAM was constructed to remove old foundation piles at the south pier before the cofferdam for the new pier foundation was sunk.

Concrete seal and pier

A shallow concrete seal was poured over the bottom of the coffer by a tremie of several sections of 10-in. flanged steel pipe coupled together and bolted to the bottom of a concrete hopper. Hopper and pipe were then picked up and lowered into the starting position by the whirley. A wood cap placed over the bottom of the tremie before lowering it into the water, prevented the pipe from being plugged with dirt. The tremie was filled with concrete and lifted slightly from the bottom, allowing the concrete to flow out, while the wood cap was retrieved by means of a wire to which it had been attached. The bottom of the pipe was at all times kept submerged in the concrete, until it was time to jump to another well. The elevation of the seal was determined by soundings.

The concrete seal was allowed several days to set up, after which the cofferdam was again unwatered, profiting by earlier experience. When the cage had been driven down it had landed on one of the old piles and was weakened. This was not apparent until the water level had been lowered, at which time the strut failed from the water pressure. The pumps were slowed down and the water level held at this point, while the broken strut was quickly replaced. It later developed that a bank of clay against the sheeting had prevented the seal from spreading thoroughly across the dam at this point, resulting in extra pressure from the sheeting at the weakened strut. No damage resulted from the failure as the steel lower wale did not give a great deal, and there was still plenty of clearance to permit building the footing according to plan.

Except as noted above, the concrete seal was found to be in good condition and reasonably true to grade. The pile tops were cut off in the open, using two-man cross-cut saws. The pier footing was then formed and poured, steel I-beam deadmen being set in the concrete at intervals around the perimeter of the footing. After the concrete had set up sufficiently the lower wales were braced against the deadmen and the lower tier of cross-struts removed to make room for the next lift of forms. The pressure against these deadmen was so great that in many instances the I-beams gave evidence of failure through buckling. The concrete pier was next poured to the level of the top bracing, internal vibrators being used to secure a well puddled job, after which the braces were shifted to bear against the pier and the cross struts were removed. When the concrete had been given time for proper curing the dam was again flooded and the steel sheet piling pulled using a pile extractor. The steel sheeting was transferred to the south side to be used again.

Details changed at south pier

A change in procedure was adopted for the south bascule pier, although conditions were practically identical. Here also the two clusters of foundation piles, supporting one of the old piers, fell within the area of the new footing. This time it was decided to remove the piles. Circular cofferdams of steel sheet piling were built around each cluster and unwatered. The old piles were started by eight parts of cable from a cross-beam thrown across the top of the cofferdam. The first two piles were completely removed as they were loosened, which resulted in blowing in the bottom and flooding the dam. Thereafter the piles were only started, and later all pulled at one time. Cable slings attached to each as it was loosened, extended to a point above water level. The cell was then flooded and each of the piles in turn lifted out by its sling.

A change was also made in the construction of the crib for the cofferdam of the south bascule pier. Steel struts, as well as wales, were used throughout the lower tier. The increased weight made it advisable to assemble the frame in place on falsework piles. To set the frame on the bottom it was first hung by cables from the steel sheeting, after which the falsework piles were pulled and the cage lowered. In spite of the above precautions one of the steel struts was damaged by the hammer while driving the foundation piles. It collapsed when the cofferdam was unwatered but again the heavy steel wale saved the cofferdam.

Little difficulty was experienced in placing the abutment foundations, which did not go as deep as the river piers. At the north abutment the old pier was retained. For the wing walls a system of well points was installed, supplemented by a sump pump, but the water could be kept down only at low tides. In view of this trouble the foundations of the south abutment were completely cofferdammed, resulting in a saving in time and money.

Northeast storms are frequently encountered along the New Jersey coast during the fall of the year. However, only one bad storm was experienced and that one occurred during the period between completion of the north river pier and the start of the south one.

Directing personnel

The new bridge is being built by Monmouth County, under the direction of John F. Hogan, supervising engineer. The design of the bridge was prepared by Morris Goodkind and Ash-Howard-Needles & Tammen, of New York City. Grover C. Denny is in charge of construction work for the contractor, Merritt-Chapman & McLean, of Baltimore, Md. The project is being financed by a loan and grant from the PWA, which maintains its customary supervision over execution of work and observance of regulations.

Grand Lake Diversion Project

The proposed Grand Lake trans-mountain diversion project in Colorado will be one of the most diversified projects ever undertaken by the U. S. Bureau of Reclamation, according to a talk made by Porter J. Preston, senior engineer of the bureau, before the Colorado Chapter of Tau Beta Pi alumni recently in Denver. The purpose of the project is the annual diversion of 310,000 acre-ft. of water from the Western Slope for irrigation of fertile plains near Ft. Collins, on the Eastern Slope of the Continental Divide. An exceptionally dry cycle during the past decade has curtailed the growing of produce in the Ft. Collins area, but with ample water for irrigation this region could produce crops five times the value of those raised at present. The Grand Lake project would embrace the construction of three large earth and rockfill dams, a power plant, a tunnel 13.1 mi. long and about 30 mi. of canals.

To guarantee Western Slope water users an adequate supply in exchange for water diverted, a dam would be constructed on the Blue River to form the Green Mountain Reservoir having a capacity of 152,000 acre-ft. On the Colorado River 10 mi. below Grand Lake the plan calls for a dam 220 ft. high to form the Granby Reservoir, which would have a surface area of 482,000 acres and a capacity of 482,000 acre-ft. About 4½ mi. above headwaters of this reservoir would be built the third dam, to create Shadow Mountain Lake. Water in this lake would reach the level of that in present Grand Lake (El. 8371) 96 ft. above the surface of Granby Reservoir.

Water from Granby Reservoir would be pumped a maximum lift of 130 ft. to a canal leading to Shadow Mountain Lake. At the head of Grand Lake a lined tunnel 13.1 mi. long will be driven under the Continental Divide, which rises to El. 14,000 at this point. The tunnel will be a horseshoe section 9 ft. in diameter and will carry 550 sec. ft.

From the east portal of the tunnel water will be conducted through a canal to a power plant in Estes Park. Under an effective head of 705 ft. the plant will develop 38,000 h.p., part of which will be transmitted across the range to be used in pumping water from Granby Reservoir to Shadow Mountain. To insure all-year operation the intake of the pump lift will be placed 34 ft. below the surface of the reservoir. Through a system of canals the water will be conducted from the Estes Park power plant to the lower Poudre River, where it can be stored in nearby reservoirs and lakes.

The entire project will cost about $34,800,000. If the market for power is sufficiently large, five other hydro plants will be built, one at Green Mountain Reservoir and the other four at intervals below Estes Park. These five additional plants would cost $19,000,000 and will develop a salable output of 360,000,000 kw.-hr. annually. This energy could be sold for 1.8 mills per kw.-hr. Sale of this large amount of power would probably pay for the cost of the entire project well within the 40-year time specified in Bureau of Reclamation projects.

In addition to supplying cheap power and developing a rich agricultural district, the creation of the large lakes and reservoirs will add to the scenic beauty of the region.

Whitewashing RA Housing

Whitewash has been found the most effective means of protecting the rammed-earth houses on the Resettlement Administration Gardendale project, near Birmingham, from the heavy rains of the region.

The houses were built a year ago by Thomas Hibben, Resettlement Administration engineer, with walls of damp earth hand-tamped into forms. Marked economies over comparable types of construction were claimed, and it was stated that the large proportion of hand labor in the construction made the type particularly well adapted to relief labor projects. Experience with the houses since their completion has been favorable, except that after standing a year in Alabama's rainy climate they began to erode and crumble.

A Count of Road Growth

In twenty years improved highways have increased to several hundred thousand miles, system classification has been adopted and public-roads management has become one of the largest activities of government

THE FRAGMENTARY *character of the highway statistics that follow is fully recognized. But until the careful road inventories and surveys of traffic and highway financing now being made by the states in cooperation with the federal Bureau of Public Roads have been completed, which will be a matter of many months, there are no better statistics available than those given below. They have been assembled by the staff of Engineering News-Record to meet an immediate demand for figures of road-mileage growth and classification, for data on road-building money received and expended, and for other quantitative and qualitative measures of American highways. Such information as is here assembled has come from many publications scattered through the years; it cannot be found elsewhere gathered in one place.*

NO PUBLIC improvement, no class of engineering construction in the United States has been subjected to as many or as good statistical studies as have highways. Vehicles served, dollars collected, dollars spent, miles in use, miles improved—a summary of these is a task of selection, not of search. Yet with all these records neatly tabulated by states, itemized, sub-classified and subtotalled, one still does not have a complete statistical picture of highway needs today. Where the missing pieces fit into the picture will show up as the pieces we do have are fitted together. To make sure of working toward a complete picture the growth of the numerous organizations for promoting, financing, building and maintaining highways is considered first.

The begetting agencies

Most men today if asked to name the greatest single influence on highway development would answer unhesitatingly—"the automobile." Yet the first good roads movement antedates the motor vehicle by several years. "It was the bicycle which brought the first impetus to highway improvement and inaugurated the period of promotion." (Half a Century of Road Development, *Engineering News-Record,* April 17, 1924). It is in 1895 that the record of motor vehicle registrations starts, and with four "automobiles." By 1906 registrations had climbed to 107,000 vehicles of which 1,100 were trucks. In 1935, 22,565,347 automobiles, 3,655,705 trucks, 227,271 tax-exempt official government cars and 733,414 trailers (including passenger-car trailers) made a grand total of 27,181,737 vehicles. This spectacular rise is shown graphically in Fig. 1.

The number of motor vehicles is only one factor; the ever increasing operating radius had a greater influence on highway development, administration and organization. Roads became more than local farm-to-market service routes and centralization of management began.

In 1891 New Jersey passed the first state-aid law with administration vested in the secretary of the state department of agriculture. Two years later Massachusetts enacted a similar law and created a commission for its administration. In that year too the federal Office of Public Roads Inquiry was set up. New Jersey amended its state-aid act in 1894 to provide for a Commission of Public Roads to administer affairs of the department. In 1902 both the American Road Builders Association and the American Automobile Association were organized. In 1903 Delaware passed a county-aid law with a state highway commissioner for each of her three counties; the $10,000 state-aid per annum had to be matched by the counties. In 1908 Maryland authorized a system of trunk line roads but roads were still predominantly a purely local concern.

From this date on the rapidly increasing numbers and use of motor vehicles speeded the movement toward highway networks and by 1916, 30 states had organized highway departments. On July 11, 1916, the Federal Aid Road Act was passed, appropriating $75,000,000 and requiring centralized state administration of all highways benefited. The principle of state and federal authority for road construction, maintenance and financing thus was established; this principle was further reinforced on Nov. 9, 1921 when the Federal Highway Act established the federal-aid system of connecting national highways.

This trend toward consolidation of highway administration into larger units has continued, though at a slower pace. In 1931, North Carolina put all roads under state jurisdiction, Michigan began the transfer, which was completed in 1936, of 60,000 miles of township roads to the county system, Pennsylvania in 1931 added 20,000 miles of township roads to her state system. In 1932, Indiana transferred all township roads to the county system and Virginia put her county roads into the state system. This year too the National Highway Users Conference was organized to promote the use of highway funds for highways and to fight the increasing diversion for non-highway purposes. In 1935, Delaware transferred her county roads to the state system.

During 1936, the six New England

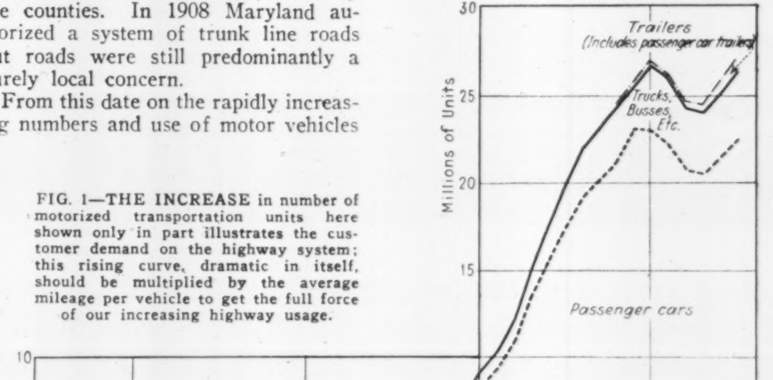


FIG. 1—THE INCREASE in number of motorized transportation units here shown only in part illustrates the customer demand on the highway system; this rising curve, dramatic in itself, should be multiplied by the average mileage per vehicle to get the full force of our increasing highway usage.

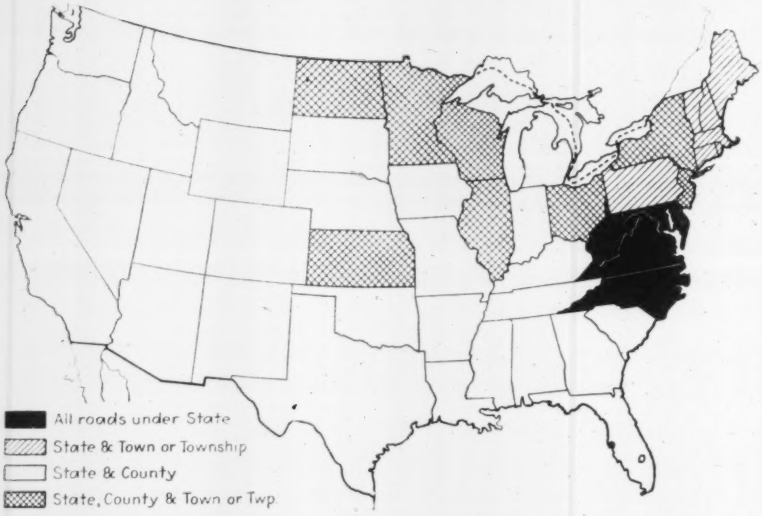


FIG. 2—RURAL HIGHWAYS administered by the states. A summary made at the beginning of 1937 shows that the state-county system is in effect in a majority of states; state system only in five states; state-town system in New England, and state-county-township system in eight states.

states had both state and town road organizations; five southern states had state organizations only; eleven eastern and middle western states had three systems, state, county and township; Pennsylvania had three systems with the largest mileage under state and township and a small mileage under county administration; Washington had township mileage in two counties but only two systems, state and county, in the rest of the state; and the remaining twenty-four states had two systems, state and county. These organizations are carrying over into 1937. Fig. 2 identifies the states according to their present form of highway organization.

This shifting of highways from one form of administration to another and particularly the setting up of state and federal-aid road systems crystallized the need for statistics of mileage, financing and expenditures. To the Bureau of Public Roads and the American Association of State Highway Officials goes the credit for systematizing and standardizing the data collected so that comparable state records add up to national totals.

Mileage growth

The first estimate on record of total road mileage in the United States is 2,151,379 for 1904. This total has increased only about 43 per cent in the succeeding 32 years, and this largely because each count was more accurate than that preceding. The record of total state mileage starts in 1921 with 202,915 mi.; by 1935 this had increased 157 per cent to 520,351 mi. Local mileage data have not been collected nationally since 1930 when the total stood at 2,684,570. Adding 324,496 mi. of highways under state administration that year to the mileage under county and township administration gives a total of 3,009,066 for the national highway total in 1930. Table I gives the complete record of this mileage increase by years, beginning with 1921, and of the gradual shift from local to state administration. The improvement status of local roads in 1930 (the last year for which national totals were compiled) is summarized in Table XIII; these figures are now antiquated and the count for 1935 is not yet available.

State highway statistics are available by states through 1935. The im-

TABLE I — GROWTH IN TOTAL RECORDED MILEAGE OF ROADS SINCE 1921 BASED ON COUNTS OF THE BUREAU OF PUBLIC ROADS

Year	Total mileage	Local mileage	State mileage
1921	2,924,505	2,721,690	202,915
1922	2,968,000	2,740,740	227,260
1923	2,995,727	2,744,116	251,611
1924	3,004,411	2,743,196	261,215
1925	3,006,082	2,731,171	274,911
1926	3,000,190	2,712,262	287,928
1927	3,013,584	2,720,231	293,353
1928	3,016,281	2,709,839	306,442
1929	3,024,233	2,710,097	314,136
1930	3,009,066	2,684,570	324,496
1931	....	....	328,942
1932	....	....	358,210
1933	....	....	480,920
1934	....	....	507,014
1935	....	....	520,351

Note — From 1931 to 1934 data on total and local mileage were not collected officially; they are now being collected for 1935. State mileage for 1933-1935 was subdivided as:

	1933	1934	1935
Primary state system	345,471	324,312	331,867
Secondary state system	135,169	170,244	173,604
Streets connecting state highways	....	12,458	14,881

TABLE II — MILEAGES OF HIGH-TYPE ROAD SURFACES FOR THE YEAR 1935 SUBDIVIDED ACCORDING TO KIND OF SURFACE

	Primary system	Secondary system	Urban links	Total by types
Total high type mileage	111,525	2,818	13,748	128,091
Bituminous macadam	14,363	881	942	16,186
Bituminous concrete and sheet asphalt	14,265	624	3,991	18,880
Portland-cement concrete	79,872	1,145	6,401	87,418
Vitrified brick	2,875	161	2,071	5,017
Asphalt block	71	.....	88	159
Stone block	12	5	207	224
Wood block	4	.....	39	43
Timber flooring on bridges	152	2	9	163

TABLE III — MILEAGES OF LOW-TYPE ROAD SURFACES AS OF THE YEAR 1935 SUBDIVIDED ACCORDING TO KIND OF SURFACE

	Primary system	Secondary system	Urban links	Total
Total low types	168,282	74,426	3,541	246,249
Top soil and soil clay,				
Untreated	8,597	16,486	132	25,215
Treated	8,541	532	211	9,284
Gravel, chert, shale,				
Untreated	67,479	35,528	925	103,932
Treated	36,542	14,929	1,085	52,556
Waterbound macadam,				
Untreated	2,765	2,063	49	4,877
Treated	16,985	495	409	17,889
Low-cost bituminous mix	27,373	4,393	730	32,496

TABLE IV — STATUS OF IMPROVEMENT OF NATIONAL FOREST AND PARKS HIGHWAYS AS OF JUNE 30, 1936

	Forest Highways		Parks and Monuments	
	Miles completed	Miles under Cons.	Miles completed	Miles under Cons.
Graded and drained	1,832.9	185.9	92.8	100.5
Sand clay	7.9	14.0*	184.0†	191.2†
Traffic bound surfaces	3,415.4	148.0	....	.....
Bituminous surface treated	591.4	98.0	299.0	27.0
Low-cost bituminous mix	565.1	47.4	422.4	203.8
Bituminous macadam	38.0	2.0	87.5	.....
Bituminous concrete	....	.....	15.8	.....
Portland cement concrete	0.1	0.2	20.5	13.5
Bridges	15.6	.....	2.1	0.7
Total improved	6,466.4	495.7	1,124.1	536.7

* Water bound macadam.
† Gravel.

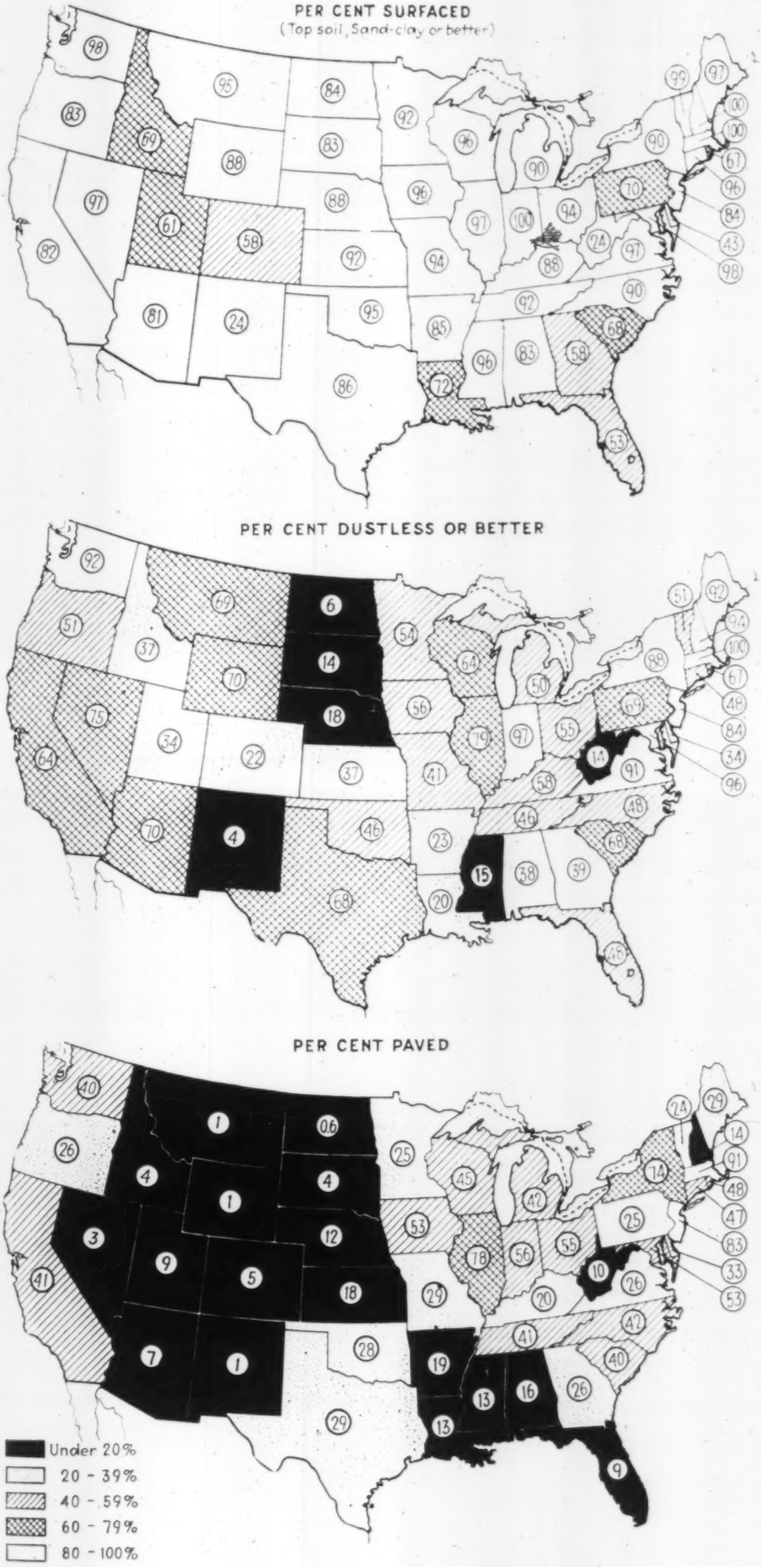

PER CENT SURFACED
(Top soil, Sand-clay or better)
98
83
69
95
84
92
96
99
97
100
100
88
83
90
90
67
97
61
58
88
96
70
96
82
92
97
100
94
84
24
97
43
94
88
98
81
24
95
92
90
85
68
96
83
58
72
86
53
PER CENT DUSTLESS OR BETTER
92
69
6
51
92
51
37
14
54
64
94
100
70
88
67
75
50
48
56
69
18
84
79
97
55
34
34
22
14
91
96
64
37
41
58
48
46
70
4
23
68
15
38
39
68
20
48
PER CENT PAVED
40
24
29
1
0.6
14
26
25
91
4
4
45
14
48
1
42
47
53
12
3
78
56
55
25
83
9
5
10
26
33
41
18
29
20
53
28
42
7
1
19
41
40
13
16
26
29
13
9
Under 20%
20 - 39%
40 - 59%
60 - 79%
80 - 100%

FIG. 3—A GEOGRAPHICAL ANALYSIS of stages of surface improvement as of January 1, 1936, shows that in only six states was the mileage of improved roads (dustless or better) under 20 per cent; in nineteen states paved mileage is less than 20 per cent. No state falls below 20 per cent in surfaced mileage—top-soil, sand-clay or better.

provement status of this mileage at the end of 1935 is summarized in tables II, III, IV, and XI. The latter shows that of the three systems under state jurisdiction 64 per cent of the mileage is on the primary system, 33 per cent on the secondary system and 3 per cent on urban links. These tables also show the national mileage of non-surfaced and surfaced, low-type and high-type roads with percentage of mileage in each class; they show as well the mileage of each of the principal types of surfacing.

To give a quick picture of how this state highway improvement is distributed, the three maps in Fig. 3 are shaded to indicate for each state the percentage of its road mileage that is *surfaced* (sand-clay and topsoil or better); the percentage that is *dustless* or better, and the percentage that is *paved*.

These mileage statistics were once an excellent measure of highway progress to date and, by inference, of the volume of work yet to be done. They still show what has been accomplished in the past but are not in their present form a complete picture of what highway work is needed. Much of the highway mileage listed as high-type surface is worn out or obsolete, the pavement narrow, alignment bad, the surface cracked, patched and rough and there are bottlenecks, narrow drainage structures and narrow bridges. A worn-out or obsolete mileage column would strengthen the statistical picture of present and future needs. Possibly the surveys now in progress will lead to this and to the setting up of mileage requirements of express, freight or other special congestion-relief highways not now included or identified in existing mileage tables.

How expenditures have grown

The next pertinent question is: what do we spend on these 3,000,000 miles of roads and how do we spend it? The national bill for rural highways in 1904 is estimated at $60,000,000. In 1930 this had increased to $1,885,850,514, an all time high. National records of disbursements begin in 1921 with $397,000,000 by state highway departments and $636,000,000 by local authorities, a total of $1,027,000,000 (omitting fund transfers). For the peak year, 1930, the states disbursed $1,140,000,000, their peak volume, and local authorities $852,000,000. Since 1930 national data on local disbursements have not been collected and state disbursements declined to $782,000,000 in 1933, returned to $992,000,000 in 1934 and $848,000,000 in 1935.

Of the total state disbursements from 70 to 90 per cent goes into "capital investment in road construction and right-of-way," maintenance, and purchase of equipment and machinery. Of the total disbursements by local administration from 64 to 82 per cent goes for these purposes.

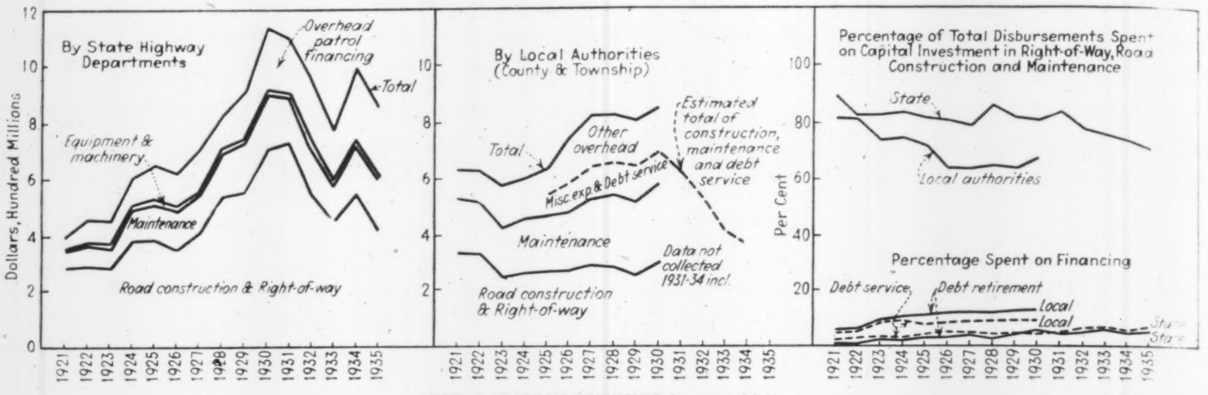


FIG. 4—DISBURSEMENTS by state highway departments are mainly for construction; overhead, patrol and financing are next in cost and maintenance and equipment are third. Local highway disbursements, when last reported, were almost equally divided between construction, maintenance and overhead including financing; more of the local than of the state highway dollar goes into overhead and financing.

Table XII reports disbursements by years. Fig. 4 shows how the states lead on construction expenditures while local authorities spend more on maintenance. The overhead and financing segment of local disbursements is larger proportionally than for the state. The percentage analysis shows that this is in part due to the fact that the debt service and debt retirement disbursements which are made by local authorities are proportionately higher than those made by states.

The complete analysis of state highway disbursements in 1935, given in Table V shows that construction of roads took 41.9 per cent; bridges, 5.3 per cent; maintenance, 21.7 per cent; equipment, 0.8 per cent; interest on highway obligations, 8 per cent; retirement of state highway obligations, 6.6 per cent; fund transfers to local roads and streets, 6.7 per cent, and transfers for non-highway purposes, 2.5 per cent. The last 2½ per cent is in addition to the direct diversion of motor-vehicle

TABLE V — DISTRIBUTION OF STATE HIGHWAY DISBURSEMENTS IN 1935 COMPILED FROM BUREAU OF PUBLIC ROADS RECORDS

	Amount	Per cent
Capital Outlay	$416,412,000	49.1
Acquisition of right-of-way	16,077,000	1.9
Construction of roads	354,950,000	41.9
Construction of bridges	45,385,000	5.3
Maintenance	184,458,000	21.7
Equipment	6,819,000	.8
Administrative, engineering, etc	30,653,000	3.6
State highway police	6,806,000	.8
Interest on highway obligations	67,918,000	8.0
Retirement of state highway obligations	55,756,000	6.6
Total Expenditures on state system	$768,822,000	90.6
Expenditures or fund transfers	$79,533,000	9.4
For local roads and streets	56,938,000	6.7
Other highways not on state system	1,228,000	.2
For non-highway purposes	21,367,000	2.5
Net expenditures for year	$848,355,000	100.0
Balance carried over to 1936		
Highway funds	$198,040,000	
Reserves for debt service	159,550,000	
	$357,590,000	
Total funds	$1,205,945,000	

TABLE VI — REVENUES FROM MOTOR VEHICLES BY YEARS (NOT INCLUDING SALES TAXES) COMPILED FROM BUREAU OF PUBLIC ROADS RECORDS

Year	Motor vehicle license	Gasoline tax	Total from motor vehicles
1904	$33,411	No tax law	$33,411
1909	942,675	No tax law	942,675
1914	12,382,031	No tax law	12,382,031
1921	122,478,654	$5,382,111	127,860,765
1922	152,047,824	12,703,088	164,750,912
1923	188,970,992	38,566,338	227,537,330
1924	225,492,252	79,734,490	305,226,742
1925	260,619,621	146,028,940	406,648,561
1926	288,282,352	187,603,231	475,885,583
1927	301,061,132	258,838,813	559,899,945
1928	322,630,025	304,871,766	627,501,791
1929	347,843,543	431,311,519	775,591,062
1930	355,704,860	493,865,117	849,569,977
1931	344,337,654	536,397,458	880,735,112
1932	324,273,510	513,047,239	837,320,749
1933	302,694,065	518,195,712	820,889,777
1934	304,928,000	591,995,712	896,923,000
1935	322,776,536	647,852,308	970,628,844

TABLE VII — SOURCE AND DISTRIBUTION OF REVENUE FROM MOTOR VEHICLES IN 1935

Receipts

Registration and other fees	$318,747,713
State motor carrier tax receipts	12,421,383
Fuel tax	619,802,062
Total	$950,971,158
Adjustments due to undistributed balances caused by registration years differing from fiscal years	10,535,048
Net total	$940,436,110

Disposition of Receipts

	Amount	Per cent
For state highway purposes	$522,129,560	55
Local roads and streets	238,133,817	25
Other highways, park and forest roads, etc	1,269,380	1
Sub-total going to roads	$761,532,757	81
Expenses of collection and administration	31,761,144	3
For non-highway purposes	147,142,209	16
	$940,436,110	100

TABLE VIII — YEARLY AMOUNTS OF FEDERAL MONEY APPROPRIATED FOR ROAD-BUILDING UNDER THE DIRECTION OF THE BUREAU OF PUBLIC ROADS

	Amount appropriated	Actual payments to states
1917	$5,000,000	......
1918	10,000,000	$425,446
1919	65,000,000	2,702,248
1920	95,000,000	19,593,431
1921	100,000,000	55,974,306
1922	75,000,000	88,205,933
1923	50,000,000	69,677,242
1924	65,000,000	79,217,398
1925	75,000,000	95,749,998
1926	75,000,000	87,754,535
1927	75,000,000	81,371,013
1928	75,000,000	80,802,233
1929	75,000,000	82,097,380
1930	75,000,000 (¹)	75,880,863
1931	125,000,000	153,637,177
1932	125,000,000 (¹)	186,274,573
1933	125,000,000 (¹)	163,398,292
1934	No federal aid (¹)	221,715,379
1935	No federal aid (¹)	274,667,774

(¹) Add Emergency Advances: 1930 — $80,000,000; 1932 — $120,000,000; Recovery Funds: 1933 — $400,000,000; 1934 — $200,000,000; Emergency Relief: 1935 — $400,000,000. These funds are not designated for any specific fiscal year.

TABLE IX — SOURCES OF STATE HIGHWAY INCOME FOR 1935 COMPILED FROM BUREAU OF PUBLIC ROADS RECORDS

	Amount	Per cent
Balance on hand Jan. 1, 1935		
Highway funds	$154,777,000	12.8
Reserves for department service	149,158,000	12.4
Total	$303,035,000	25.2
State road levies	1,929,000	0.2
Appropriations from general funds	5,914,000	0.5
Motor fuel taxes	392,658,000	32.6
Motor vehicle registration fees, etc	188,433,000	15.6
Motor carrier taxes	5,955,000	0.5
Tolls on state highway bridges, ferries, etc	2,772,000	0.2
Other state taxes, fees, etc	349,000	....
Sub-total from current state revenue	$598,010,000	49.6
Miscellaneous state highway income	8,370,000	0.7
Federal aid, regular payments	215,239,000	17.8
advances to trust fund	—1,823,000	—.1
Other federal funds (oil royalties, work relief, etc.)	5,965,000	0.5
Funds from local government units for work on state highways	16,904,000	1.4
for work on local roads and streets	3,462,000	0.3
Income from bond issues, etc	55,883,000	4.6
Sub-total from other than state sources	$304,000,000	25.2
Net state highway income	$902,010,000	
Total funds on hand for year 1935	$1,205,945,000	

TABLE X — MAJOR HIGHWAY CONSTRUCTION VOLUME AS REPORTED BY ENGINEERING NEWS-RECORD

	Total bridges	Public bridges	Highways
1913	$22,630,000	....	$57,408,000
1914	33,047,000	....	72,818,000
1915	23,331,000	....	78,038,000
1916	41,513,000	....	156,938,000
1917	24,039,000	....	103,365,000
1918	17,237,000	....	73,794,000
1919	27,144,000	....	225,655,000
1920	33,801,000	....	262,641,000
1921	29,730,000	....	313,303,000
1922	43,477,000	....	334,694,000
1923	66,985,000	....	361,837,000
1924	68,564,000	....	415,216,000
1925	69,876,000	$63,321,000	421,039,000
1926	83,383,000	78,071,000	484,898,000
1927	143,645,000	121,137,000	525,069,000
1928	130,203,000	99,702,000	615,279,000
1929	135,588,000	99,315,000	539,352,000
1930	129,573,000	110,554,000	576,993,000
1931	136,888,000	104,737,000	528,512,000
1932*	83,832,000	79,557,000	379,937,000
1933*	97,831,000	80,890,000	288,258,000
1934*	98,844,000	88,800,000	345,066,000
1935*	97,933,000	86,861,000	325,263,000
1936†	178,382,000	166,567,000	472,477,000

Maintenance is not included but major reconstruction is, for federal, state municipal, county and other highway or bridge projects of $25,000 value and over. * $17,500 minimum value. † $23,000 minimum. Adjustment in proportion to *ENR* Construction Cost Index.

and fuel revenue which will be reported in the discussion of revenue statistics.

Where the money comes from

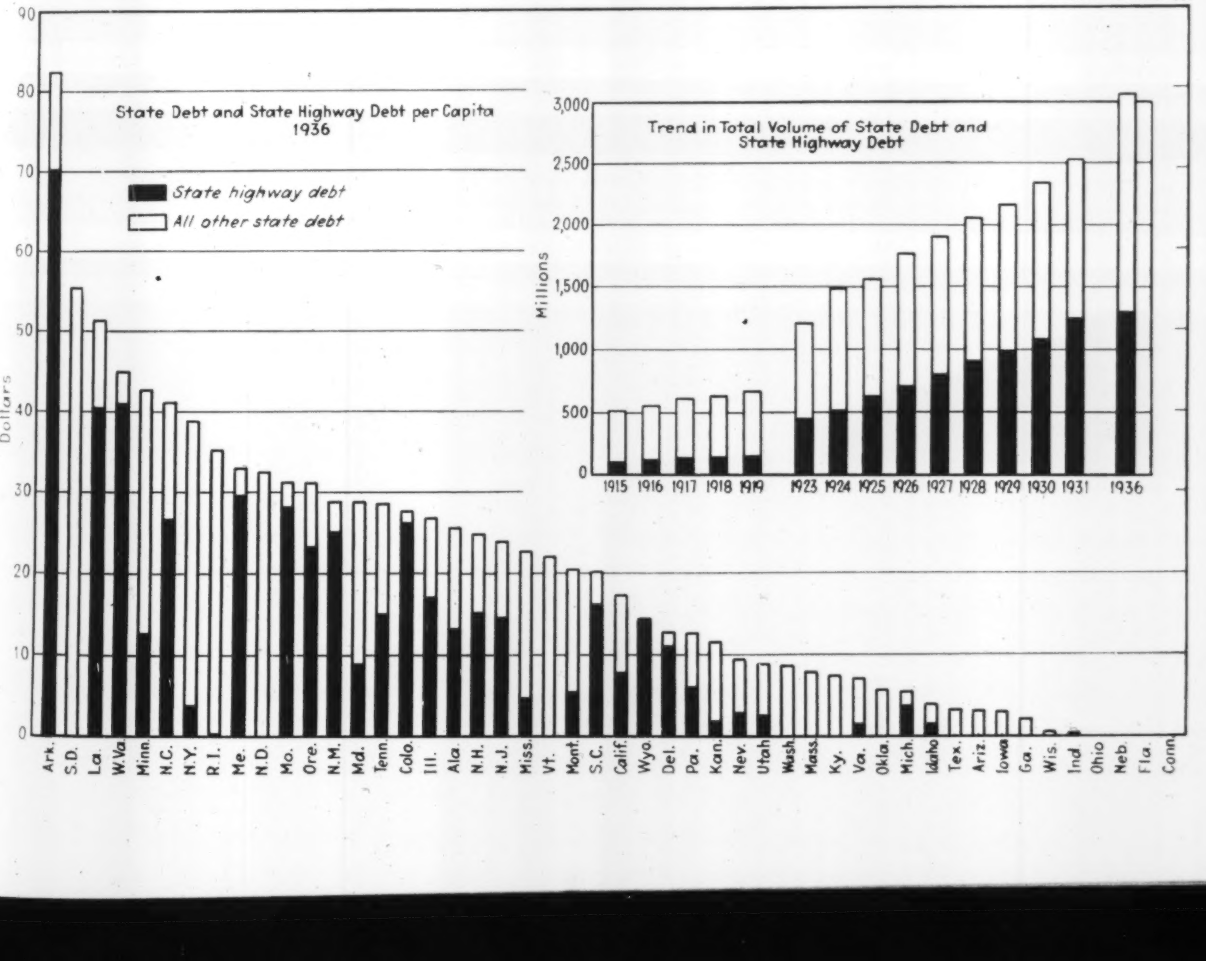
Expenditures seem to inspire complete statistics, but where all this money comes from is not so thoroughly recorded. State statistics are available and analyzed in the thorough way we have come to expect of the Bureau of Public Roads and the state highway departments, but local data are fragmentary and incomplete, both chronologically and geographically.

One source of course is the money borrowed. Annual sales of state and municipal bonds for streets, highways and bridges have been recorded by the *Commercial and Financial Chronicle* since 1902. Beginning at $24,000,000 (Table XIV) they rose to $433,000,000 in 1930, the peak year, and declined to $37,000,000 in 1933. Table XIV also shows the retirement of outstanding bonds by years, 1921 to 1935 by state and local highway organizations. Data are not available for cities.

Outstanding highway obligations of states totalled $1,307,469,703 in 1936 according to studies by the municipal service department of Dun & Bradstreet published in "Borrowing for Highways." Sixteen states have no highway bonds outstanding. In the thirty-two states that have borrowed money for highways, the outstanding per capita debt of Arkansas is $70; of Louisiana and West Virginia, between $40

FIG. 5—STATE INDEBTEDNESS for highways is confined to 32 states. In one of these states it has reached to $70 per capita. Total state highway indebtedness has grown from $422,000 in 1894, to $93,293,067 in 1915 to $1,307,469,703 in 1936.

Dun & Bradstreet



and $50; of six states, from $20 to $30; of nine states, from $10 to $20; and of the remaining fourteen states, under $10. The median per capita highway debt for these thirty-two states is $13.38. Fig. 5 shows both the present outstanding per capita debt by states and the trend since 1915 in total amount of state highway obligations.

Property taxes for highway purposes are not recorded in national totals but are being reported for a few individual states as 1932 financial surveys are worked up.

The motor vehicle has exerted a powerful influence on highway financing. Once tolls, then improvement taxes on land, were the primary source of highway revenue. Today revenue from motor vehicle license fees and fuel taxes are the primary source. These motor vehicle revenues have increased from $33,411 in 1904 to $970,628,844 in 1935, as shown by Table VI.

This motor vehicle revenue, originally used for state highway financing, is no longer concentrated on state highway systems. In 1935 only 55 per cent was devoted to state highway purposes, 25 to local roads and town and city streets and 16 per cent was diverted by state legislatures for non-highway purposes. The source and disposition of this revenue is analyzed in Table VII. Another important source of state highway revenue since 1917 has been the appropriations for federal aid. These are recorded in Table VIII.

These three sources of revenue, motor vehicle license fees, fuel taxes and federal aid, accounted in 1935 for 66.5 per cent of state highway gross income. Carryover balances from the previous year and reserves for debt service account for another 25.2 per cent and income from bond issues for 4.6 per cent. This leaves 4.7 per cent of the gross income from all other sources—state road levies, appropriations from general funds, tolls, other state fees, funds from local government units and miscellaneous other highway income. Table VII shows this distribution by dollar volume as well as by percentage.

Timelier figures needed

All these statistics, excellent as they are in their content, are historical by the time they are available for use. The minimum lag is six or nine months and many reports are not available until one, two, even four years after the period represented has closed.

For watching the immediately current pulse of highway construction activity, the highway and bridge construction volume statistics reported weekly by *Engineering News-Record* are useful. These statistics report for the 48 states and District of Columbia the dollar volume of contract or force-account projects totalling $25,000 or over in size, federal, state, county, borough, township and municipal. This minimum value or "screen" for selecting a corresponding class of construction in each state and from year to year was lowered in 1932, in direct proportion to the drop in the *Engineering News-Record* Construction Cost Index, to $17,500, then raised to $23,000 during 1936 following the Cost Index increase and for 1937 returned to $25,000 since the cost index has returned to the pre-1932 average.

This statistical series for both bridges and streets and roads goes back to 1913, but "public" bridges are separated from "private" bridges only since 1925. This complete annual record of the trend of bridge and highway construction activity since 1913 is given in Table X.

For major highway volume 1936 was the best year since 1931 and equaled the 1926 volume. Bridges, with due credit to the grade crossing elimination program, topped all previous records.

The statistical stocks are far from exhausted by the selections made from them for this summary. Man hours of labor, traffic densities, materials consumed in highway construction, employment on highway construction, have all received attention, some items more exhaustive than others.

The statistical records summarized here, however, are the data which are now available to show: the number of customers who use the roads, the rural mileage available for their use, its status of improvement (but not its condition), what it has cost up to 1935, what the users have paid directly toward this cost and what other revenue has been raised for roads.

Data that are missing

In fitting these data together the following missing pieces prevent us from seeing a complete statistical picture of our present highway needs and problems: no national record of worn-out or obsolete mileage in the high-type surfaced class, no national data on additional lane-mileage needed for congestion relief, no national data on obsolete bridges or other traffic bottlenecks. Up-to-date national summaries of local mileage, expenditure and income sources are needed to guide policy toward consolidation of smaller administrative units. Historical records of local highway income and revenue sources are fragmentary and incomplete. National municipal mileage, expenditure and income statistics are nonexistent. Traffic surveys have not yet graduated into national summaries of results on which lane-mileage needs can be gauged.

The combined traffic, financial and road-use surveys for which reports were published in 1936, comprehensive as they are, are based on 1932 data. The highway budget, "Estimated Highway Expenditures" which was compiled by the Bureau of Public Roads annually

MILESTONES ALONG THE ROAD TO MODERN HIGHWAY DEVELOPMENT

1884	**Low-wheel model bicycle introduced**
1887	**The League of American Wheelman organized, worked for better roads**
1888	**The pneumatic tire for bicycles**
1891	**New Jersey—First state-aid law for roads**
1893	**Massachusetts — Similar law passed**
1894	**Federal Office of Public Roads Inquiry established**
1902	**American Road Builders Association organized** **American Automobile organized**
1903	**Delaware—County-aid law passed**
1908	**Maryland — Authorized system of trunk line roads**
1910	**California—State highway act authorized $18,000,000 bond issue** **Louisiana organized State Highway Department**
1912	**Ohio adopted state system**
1913	**Iowa established highway commission** **Michigan — Trunk-line highway act passed**
1914	**North Dakota adopted state aid** **American Association of State Highway Officials organized**
1916	**Federal-aid road act passed; $75,000,000 appropriated**
1917	**New Jersey—State Highway System established**
1921	**Federal Highway Act—federal-aid system of connecting national highways established**
1931	**North Carolina—All roads put under state jurisdiction** **Michigan — Transfer of township roads to county system begun** **Pennsylvania—20,000 miles of township roads added to state system**
1932	**Indiana—Counties took over township roads** **Virginia—County roads put into state system** **National Highway Users Conference organized**
1935	**Delaware — County roads transferred to state**
1936	**Michigan — Transfer of 60,000 miles of township roads to county system completed**

TABLE XI — MILEAGE BY TYPES OF SURFACES OF HIGHWAYS UNDER STATE JURISDICTION IN 1935 COMPILED FROM BUREAU OF PUBLIC ROADS RECORDS

	Primary miles	Per cent	Secondary miles	Per cent	Urban links miles	Per cent	Total miles	Per cent
Total	331,867	100	173,603	100	17,932(1)	100	523,402(1)	100
Non-surfaced	52,060	16.7	96,359	35.5	643	3.6	149,062	23
Partly graded	32,110	9.7	52,681	30.3	355	2.0	85,146	16
Fully graded	19,950	6.0	43,678	25.2	288	1.6	63,916	12
Surfaced	279,807	84.3	77,244	44.5	17,289	96.4	374,340	72
Low type	168,282	50.7	74,426	42.9	3,541	19.8	246,249	47
High type	111,525	33.6	2,818	1.6	13,748	76.6	128,091	25

(1) Does not include 802 miles in five states for which mileage by types of surface was not reported, nor 218 miles not segregated from primary system

TABLE XII — HIGHWAY DISBURSEMENTS BY YEARS SINCE 1911 TO AND INCLUDING 1935

	Rural highway expenditures (Fund transfers omitted)	State highway department disbursements	Per cent of total spent on cap. invest. and maint.	Local — county and township expenditures	Per cent of total spent on cap. invest. and maint.
1904	$60,000,000 est.	....	..	....	..
1921	1,027,398,489	$397,483,721	90	$636,366,111	82
1922	1,047,106,276	451,775,710	83	630,000,000	82
1923	1,007,589,798	447,362,357	83	577,831,087	74
1924	1,177,433,068	605,665,207	84	600,437,488	75
1925	1,241,049,093	649,125,101	82	639,814,606	72
1926	1,276,697,594	621,744,210	81	751,570,652	64
1927	1,419,435,323	707,179,148	79	829,177,445	64
1928	1,556,883,410	830,264,909	86½	832,142,000	65
1929	1,615,519,338	910,485,000	82	807,715,000	64
1930	1,885,850,514	1,139,677,000	81	851,687,000	68
1931	....	1,091,009,000	84	(National data	..
1932	....	955,446,000	78	not collected	..
1933	....	782,006,000	76	1930–1934	..
1934	....	991,774,000	71½	inclusive)	..
1935	....	848,355,000	71½	(Data being collected)	

TABLE XIII — HIGHWAY MILEAGE ADMINISTERED BY LOCAL AUTHORITIES AS OF 1930 COMPILED FROM THE RECORDS BUREAU OF PUBLIC ROADS RECORDS

	Miles	Per cent
Non-surfaced	2,217,232	82
Surfaced	467,338	18
Low type	425,742	16
High type	41,596	2
Total	2,684,570	100

TABLE XIV — BOND SALES FOR STREETS, ROADS AND BRIDGES FROM 1921 TO 1935, IN MILLIONS OF DOLLARS

		Principal payments	
Year	Bond sales	State and local	States only
1921	393	46	7
1922	344	46	6
1923	314	71	15
1924	381	84	17
1925	393	100	26
1926	365	113	22
1927	408	135	31
1928	408	131	28
1929	402	148	42
1930	433	182	69
1931	312	...	57
1932	164	...	54
1933	37	...	56
1934	72	...	59
1935	107	...	56

for a number of years up to 1932, has been discontinued since that date.

In other words, our present national highway statistics are all bookkeeping, no budgeting.

However, the Hayden-Cartwright Act of 1934 authorized for the first time federal funds for use in planning future work. A similar authorization is contained in subsequent legislation. This financing increases the scope of data gathering. Planning surveys are under way in 31 states and 9 more states have indicated their desire for them. The work is conducted by the state highway department, with a Bureau of Public Roads representative assigned to it to coordinate plan and method that data from each state may be comparable with those of all others. The survey plan embraces a road inventory (including condition of existing roads), a traffic survey (character and volume), a financial and road-use survey (source and distribution of highway revenue). Each state survey is to be carried on for one year. The Bureau of Public Roads as sponsor believes "that the surveys will result in the assembly of all the facts necessary for the formulation of a definite economically and socially defensible, integrated highway-improvement program."

◆

Irrigation Prospects Good in the West

GOOD SUPPLIES of irrigation water for most parts of the Western States are reported by the Bureau of Agricultural Engineering in its April snow survey statement. Conditions are unfavorable in a few states.

Arizona: Look for better than normal supply. Storage prospects excellent.

California: Substantial improvement in northern section; southern sections report continued favorable prospects. Storage conditions excellent throughout the State.

Colorado: Accumulated snow in the mountains, except in San Luis and San Juan Basins, considerably less than at this time last year. Storms late in March improved conditions in northern and central areas. Soil moisture conditions excellent except in Arkansas Valley. Reservoirs on plains and on tributaries of South Platte, except on the higher areas, about normal. Arkansas River storage low.

Idaho: Severe shortage expected by areas dependent upon unregulated streams; valleys protected by storage will benefit from carry-over from 1936. Soil is dry, and water yield of snow at altitudes about 5,000 ft. expected to be below 1936.

Montana: Some improvement over February conditions as a result of spring storms, but summer prospects are not encouraging. Conditions in western mountains better than in eastern sections.

Nevada: Flow of eastern streams expected to be 60 to 75 per cent of normal; western streams, 90 to 100 per cent. Storage in eastern and central sections low.

New Mexico: Conditions generally improved by storms late in March. Snow accumulation is heavy in the northwestern mountains. Storage in the larger reservoirs reported about normal.

Oregon: Runoff expected to be low throughout the State. In southern and central portions carry-over storage from 1936, with good soil moisture should protect irrigation requirements. Eastern stream discharge will be much below 1936, and reservoirs, except Owyhee, will hold less than last year, though sustained low-water flows are expected. Precipitation in Mid-Columbia Basin materially below normal, and soil moisture conditions not favorable, irrigation needed already in places.

Utah: In general, water supply prospects excellent for entire State, but best in south. Streams draining west slope of Wasatch Range have prospects far better than 1936. Conditions east of the Wasatch varied, but generally favorable. Soil moisture conditions ideal.

Washington: Prospects for Columbia Basin above mouth of the Snake River, slightly less promising than in 1936, but some improvement is expected. Less water in the form of snow in Yakima Basin than last year. Southeastern section facing severe shortage.

Wyoming: Accumulated snow definitely less than at this time last year, but soil moisture conditions much improved by recent storms. Northern reservoirs will fill. Storage in Pathfinder Reservoir greater than last year, but still much below normal.

Laminated Timber Arches Support Municipal Auditorium Roof

AN INTERESTING application of WPA funds has been made in Jamestown, N. D., where a long-needed municipal auditorium has been built with relief labor to an unusual design involving the use of laminated timber arches. The cost was unusually low, the total being $17,000, of which the WPA supplied $12,000 and the city of Jamestown $5,000. The resulting structure has a seating capacity of 3,000, and provides 24,000 sq.ft. of unobstructed floor space. A company which owned an old mill in the town donated the lumber in return for the complete wrecking and clearing of its property, and this contributed substantially to the low cost.

The ten arches of 120 ft. span required in the 200 ft. length of the building are of a so-called "trussless" type patented by J. H. Keefe, assistant manager, U. S. Bureau of Air Commerce, Salt Lake City. It is claimed that the material cost is low compared to other types of arches, while other advantages for this particular job were that the arches could be fabricated by common labor under carpenter supervision and that work on them could continue without interruption during cold weather.

The arch makeup is shown in Fig. 2, eight 1x12-in. planks forming the flanges while the web consists of two stacks of 4x3-in. timbers, the whole held together by two $\frac{5}{8}$-in. dia. machine bolts 2 ft. long. As a preliminary to arch assembly, 2x4's were laid on the ground radially, and the arch intrados marked on them. Along this line, 2x4-in. stakes 3 ft. long were driven 2 ft. into the ground and braced with a 2x4 on the face toward the inside of the arch. An effective template thus was provided.

Assembly began at one end of the arch by laying the 1x12's of the lower flange against these stakes, staggering the ends about 6 ft. so that joints in adjacent timbers would not coincide. As each of the eight 1x12's was placed it was held to the others by clamps and then nailed, care being taken not to drive nails at locations of the bolt holes which were to be drilled on 2 ft. centers 2 in. in from each edge. These holes were drilled in each timber immediately after it was placed.

After the eight 1x12's of the bottom flange had been placed and nailed together, the two stacks of five 3x4's were assembled in the same manner, also drilling bolt holes in them and also staggering their ends 6 ft. In addition, care was taken that the joints in one stack of 3x4's would not be opposite those in the other stack. Bending of these web timbers to the arch outline proved somewhat difficult until the expedient of ripping them for several feet in from each end was tried. They then bent readily but, to keep them in position, lag screws had to be used instead of the nails that were satisfactory in the 1-in. flange timbers.

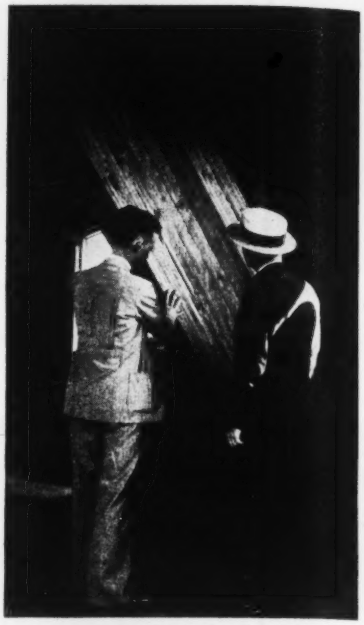


FIG. 3—LAMINATED TIMBER arch, 12 x 24-in. in cross-section and of 120 ft. span, as used in municipal auditorium at Jamestown, N. D.

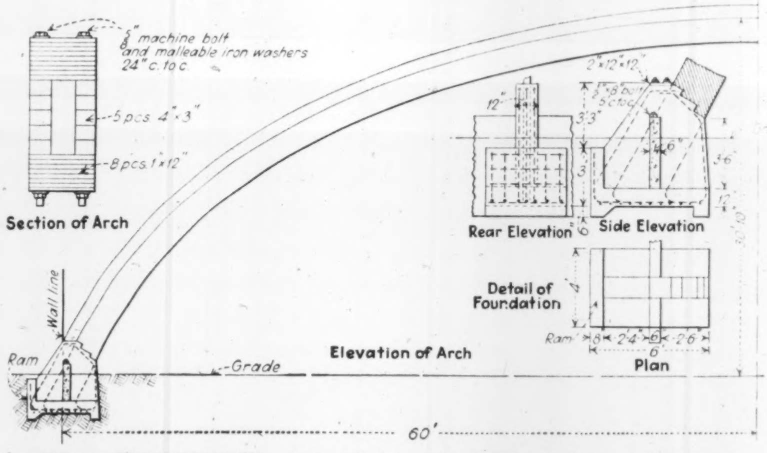


FIG. 2—CROSS-SECTION and details of laminated timber arches and their concrete abutments.

The next operation of assembly consisted in applying the 1x12's of the outside flange, after which the bolts were inserted. The work of tightening the bolts began at each end of the arch simultaneously, advancing toward the center, as an aid in inducing compression in the outer timbers and tension in the inner ones.

During the time that the ten arches were being fabricated, work was under way on the foundations. Since the auditorium had only a dirt floor, tie rods between the ends of the arches were

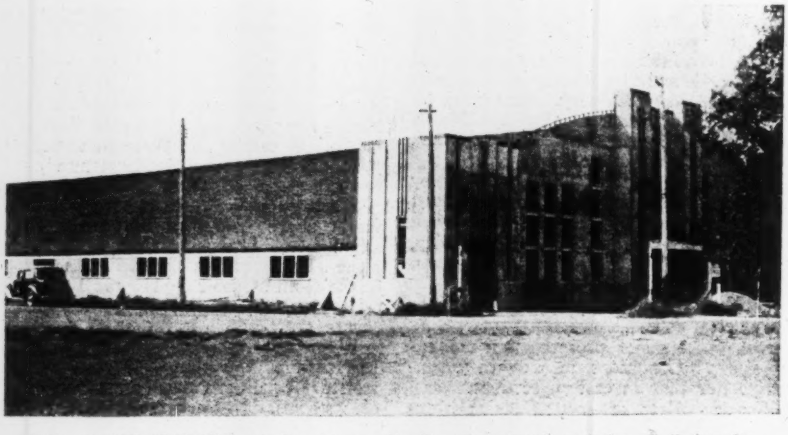


FIG. 1—AUDITORIUM at Jamestown, N. D., constructed entirely of timber by relief labor.

not practicable, and a foundation was required that would take all of the arch thrust. As shown in Fig. 2, each arch abutment is unusual in that in addition to projections on the bottom of the slab to resist sliding, the slab is literally turned up at the back to provide a substantial bearing surface or ram against the surrounding soil. Reinforcing consists of ½-in. round bars. Between the several abutments is built a 6-in. integral curtain wall.

Insofar as the balance of the building is concerned, conventional practice prevailed. Joists 18 ft. long of 2x10-in. timbers span between the arches on 2 ft. centers and are braced by double bridging at their third points. The roof sheathing consists of 1x6-in. white pine laid parallel with the arches and covered with mineral surface roofing. Side walls are relatively low as shown in Fig. 1. They and the end walls consist of 6 in. fir drop-siding attached to 2x4-in. studs placed on 2 ft. centers.

Edward E. Tufte, WPA area engineer was in charge of the project and Clinton B. Roberts was foreman. Gilbert Horton, Jamestown city engineer designed the facade of the building and represented the city as supervisor and consulting engineer.

Welded Road Bridge Girders Built on 70-ft. Span

By O. M. Bloch
Chief Engineer, The Standard Engineering Corp., Albany, N. Y.

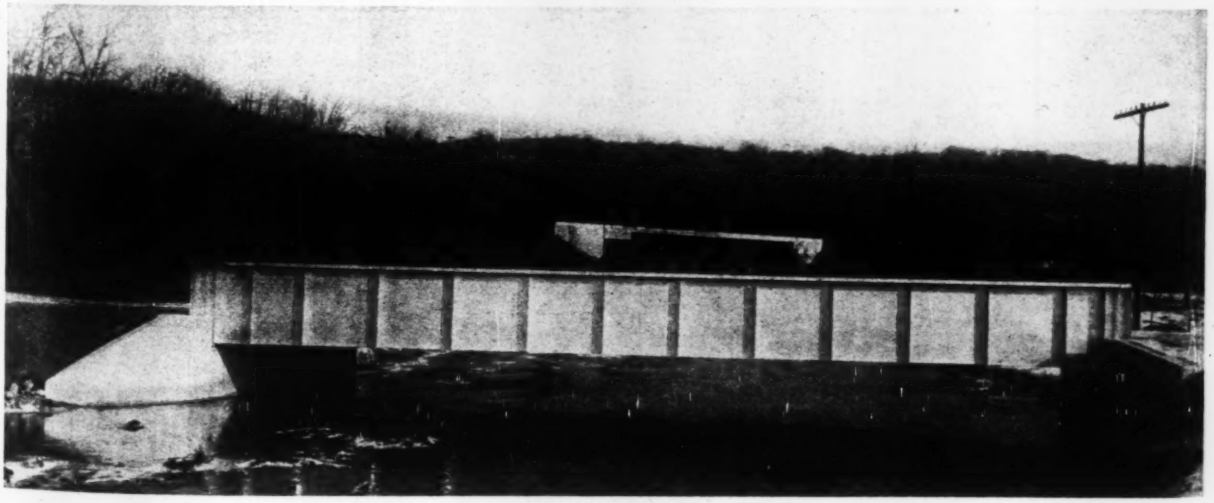
THE new Sullivan County bridge near Livingston Manor, N. Y., marks the first use of welded plate girders for a highway bridge in New York State, and the 71-ft. 8-in. length of the girders rate them among the longest yet built in this country. (Welded plate girders over 200 ft. long are in use on the German express highways.—Editor) The bridge was designed for double H-20 loading, and the girders, set 22-ft. 8-in. center to center, are 72-in. deep. Floorbeams consist of 18-in. 114-lb. rolled sections spaced 5 ft. 10 in center to center and support a reinforced concrete slab; no stringers are used.

The girders were fabricated from a 72 x ⅜ in. web plate, spliced at the center of the span, a top flange consisting of a 15-in. 45-lb. channel with flanges turned down, and a 16 x ¾-in. plate for a bottom flange. Web stiffeners are used only on the outside face of the girders, the floorbeams, floorbeam connection angles and knee braces being designed to serve as inside stiffeners. This expedient reduced the field welding and permitted some saving in material. The end stiffeners are 6 x ½-in. and the intermediate stiffeners 5 x ⅜ in. plates.

The centerline web splice is made with two 24 x ⅜ in. plates welded along their edges and also by plug welds through four 3-in. diameter holes. No flange splices are used, the plate and channel being continuous. The calculated weight of one welded girder, shop assembled, was 14,350 lb. as compared to 18,750 lb. for an equivalent riveted girder, giving a saving in material of nearly 23½ per cent.

No difficulty was experienced in the shop work on account of distortion. This was due to the fact that the welds were kept as small as possible (⅜-in. fillets), and also to the welding procedure in which all welds were laid down in short runs by the step-back method and in addition were applied uniformly over all parts of the work, thus equalizing cooling strains over the whole girder. Heavy-coated electrodes were used for both shop and field welds.

The Standard Engineering Corp., of Albany, N. Y., designed the bridge for A. C. Toaspern, county superintendent of highways of Sullivan County and inspected and supervised all shop and field welding. The Lackawanna Steel Construction Corp., Buffalo, N. Y., fabricated the girders, and county forces erected the bridge.



LONG WELDED GIRDERS in a New York county highway bridge. Note web splice on centerline (below) and in the deck view (right) the floorbeam kneebraces serving as inside stiffeners.

Fort Peck Shaft Lining

Steel diaphragms encased in 5-ft. shell of reinforced concrete form the lining of four 60-ft. diameter shafts for control of water through diversion and outlet tunnels—special rigs aid in placing concrete

By Capt. A. W. Pence
Corps of Engineers, U. S. Army, Fort Peck, Mont.

UNDER the right abutment of the Fort Peck Dam, at a maximum depth of over 200 ft., lie the four tunnels, 24 ft. 8 in. in diameter, through which the Missouri River will be permanently diverted. Near the axis of the dam each tunnel is intercepted by a 50-ft. diameter main shaft that will house the cylinder gates by which flow past the dam will be controlled. Lining of these large shafts, which were excavated 60 ft. wide, is one of the most interesting construction features of the Fort Peck project. The lining, exclusive of the ground-bracing system, consists of a 5-ft. shell of reinforced concrete in which is embedded a steel-plate cylinder. This unusual construction was made necessary by the peculiar character of the rock through which the shafts are sunk.

The four main shafts, 125 ft. c. to c., are immediately downstream from four smaller rectangular shafts for emergency-gate control.

Sinking of the shafts by the glory-hole method and installation of ground bracing of 1/8-in. steel liner plates held by vertical steel wales and horizontal ring trusses was the subject of an article published in *ENR* Aug, 29, 1935, p. 296. The bracing system is shown as a detail in Fig. 3, and can also be seen in Fig. 2. Forcing grout behind the liner plates equalized the load on the bracing, kept the shale rock firmly in place and prevented disintegration of the shale by weathering.

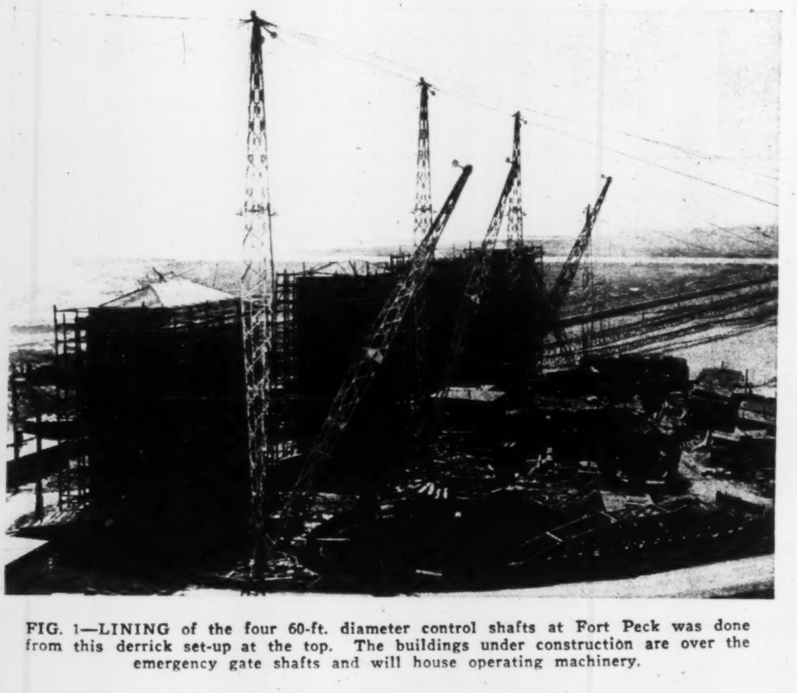


FIG. 1—LINING of the four 60-ft. diameter control shafts at Fort Peck was done from this derrick set-up at the top. The buildings under construction are over the emergency gate shafts and will house operating machinery.

Foundation structures

To avoid the hazard of a cave-in, excavation of the big shafts was halted at El. 2,110 until the foundation structures immediately upstream and downstream were excavated and lined with concrete (Fig. 3). Excavation was then resumed and carried to grade, including belling out to the octagonal shape below El. 2,080. The octagonal shape was braced with structural steel, corrugated sheets and grout. (Fig. 6). Above the tunnel this bracing was backed by a timber framework clear across the opening at vertical intervals of 8 ft. 4 in. Opposite the tunnel opening the backing was accomplished by horizontal trusses firmly anchored into the concrete already poured upstream and downstream of the big shaft. This arrangement permitted the passage of the tunnel enlargement and lining machinery which had to go by this point before the shaft was lined.

As soon as the excavation was complete, a 7-ft. reinforced concrete invert was poured, concrete being brought from a mixing plant at the inlet portals by train through the pilot tunnel and dumped by gravity and chute from a trestle bridge, the steel legs of which were buried in the pour.

Welded steel shell

The invert, sidewalls, and roof of the foundation structures immediately upstream and downstream of the big shaft had been poured with an inside surfacing of 1-in. steel plate, full strength, butt welded. This steel surface shell was anchored back into the concrete with one foot lengths of 4-in. Z-bar welded to the back of the plates on 2-ft. centers each way. Plans called for the steel plate to be continuous across the invert of the big shaft, and for the sides and roof to be framed into a cylindrical steel shell 54 ft. in diameter which would rise from the invert steel (Fig. 3). This cylinder extends up to ground surface, thereby providing a continuous steel shell for the shaft and the adjacent foundation structures. The space between the steel shell and the excavation bracing was filled with reinforced concrete and the inside of the shell was protected by a 2-ft. thickness of reinforced concrete, except at the base, where two heavy foundation blocks were provided.

Special invert

In order to bond the invert concrete to the steel lining, concrete was stopped 5 in. below the grade of the bottom of the plate and 3/4-in. hair pins 21 in. long, were placed to protrude 4 in. above the top of the concrete in between the spaces to be occupied by 4-in. Z-bars on the bottom of the invert plate (Fig. 5). After the steel was in place, the space between plate and concrete was filled with 1:1 grout, embedding both the Z-bars and the tops of the hairpins.

The placement of the steel invert

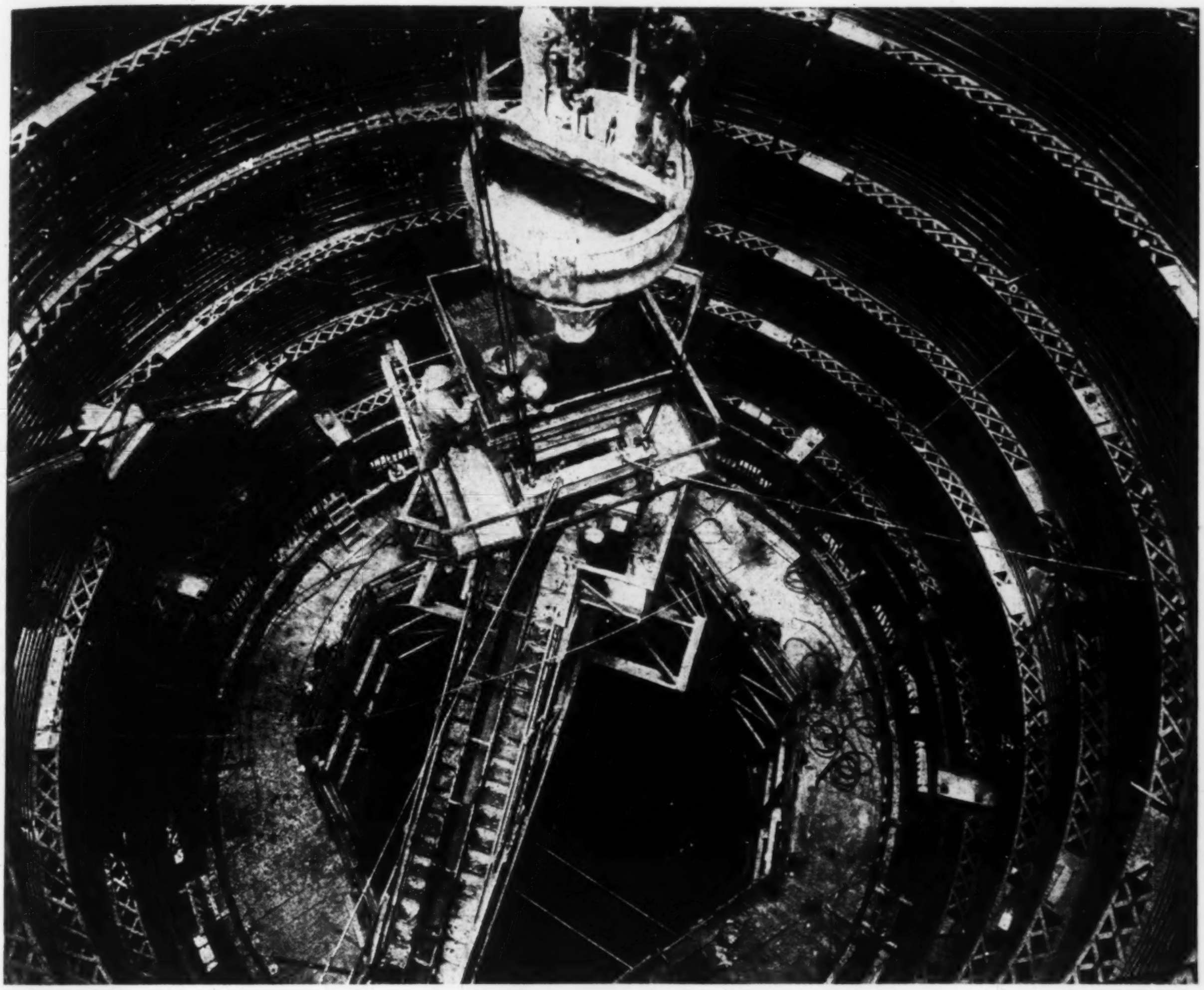


FIG. 2—CONCRETE for the 5-ft. lining wall is delivered from a 4-yd. bucket to the form by a "whirligig" spouting system. Note the heavy reinforcing between the horizontal ring braces.

(consisting of 8 x 14-ft.) plates presented several problems, such as spacing of weld throat, warping due to welding and locked up stresses which had to be overcome. Since the shaft invert plates had to fit between invert plates already concreted into the foundation structure immediately upstream and downstream, it was found advisable first to lay all plates in position and insert wedges in the weld throat to make the weld spacing uniform across the floor. The plates were then tacked and two or three passes were made over the bottoms of all weld grooves. Experience showed that considerable restraint was necessary to prevent warping of the plate after the third pass, so it was at this stage that the grout was poured. The embedment of the Z-bars in grout provided the necessary restraint for further welding and no further trouble with warping was experienced as the full strength single V-welds were completed. To remove locked up stresses and prevent cracks, a step-back welding procedure was established whereby work was started near the longitudinal centerline of the tunnel and continued out toward the edges which were free to move. Each welder deposited three coated electrodes and then skipped 2 ft. before depositing three more. Peening the hot deposit was started as soon as the welder moved to the next location.

Shafts worked in rotation

In carrying the steel and concrete lining of the shafts from the invert to the surface, lifts of 16 ft. 8 in. were adopted and the work was divided into four operations as follows: (1) placement of steel reinforcing, (2) placement and welding of steel plate, (3) form movement, (4) concrete. Gangs were organized for each operation and all four shafts were worked together so the gangs could move from one shaft to another in rotation. The entire work was on a 24-hr. basis in order to finish before cold weather and careful scheduling of work and balancing of gangs was necessary to insure smooth and continuous operation.

The cylindrical shell was composed of plates 8 ft. 4 in. wide in the vertical direction and 28 ft. 4 in. long. Thickness varied from 1 in. at the foundation to ½ in. at the top. These were bent at the mill and shipped with edges beveled for welding and with erection angles welded on. Experience showed that the plates should be shipped and stored standing on edge to avoid damage. To facilitate handling, guy derricks serving each shaft (Fig. 1) at the surface, handled the sections into the hole where they were bolted into position and then welded. A full strength weld was provided on all work below El. 2,080 and on vertical joints above that level. Horizontal joints above El. 2,080 were water-tight only (Fig. 5).

Welding the cylinder

The same welding procedure which had proven so satisfactory in the invert was applied to the cylindrical wall up to El. 2,080, except that here the Z-bars were embedded directly in the

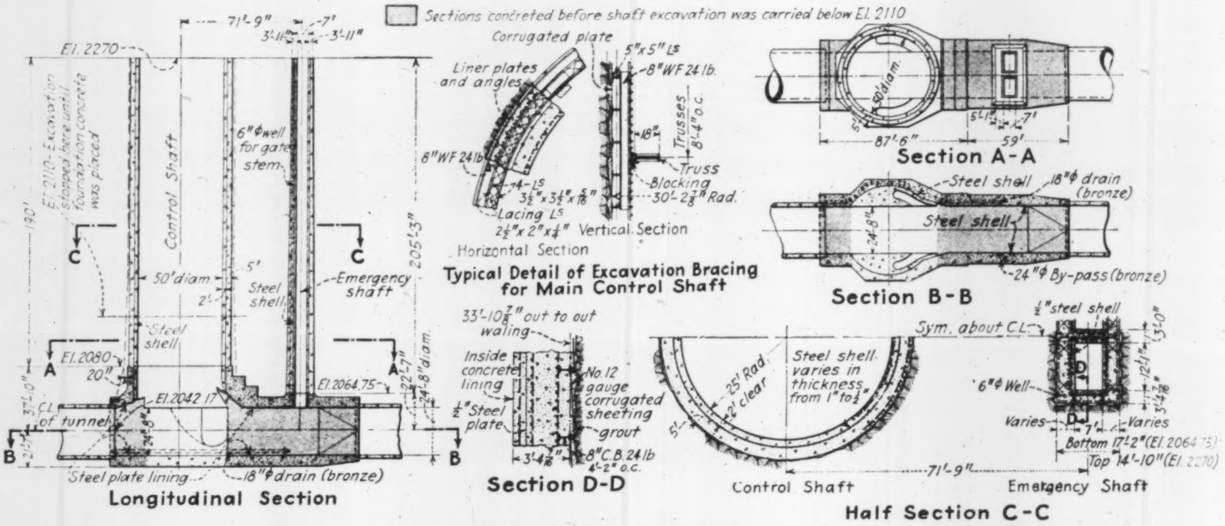

Sections concreted before shaft excavation was carried below El. 2110
El. 2270
71'-9"
7'
3'-11"
3'-11"
El. 2110—Excavation stopped here until foundation concrete was placed
Control Shaft
6"φ well for gate stem
50' diam.
Steel shell
Emergency shaft
C
C
A
A
B
B
El. 2080
El. 2042.17
El. 2064.75
of tunnel
Steel plate lining
18"φ drain (bronze)
Longitudinal Section
Corrugated plate
Liner plates and angles
5"x5" Ls
8" WF 24 lb.
Trusses 8'-4" o.c.
Truss
Blocking
30'-2⅞" Rad.
Lacing L5
Horizontal Section
Vertical Section
Typical Detail of Excavation Bracing for Main Control Shaft
33'-10⅞" out to out waling
Inside concrete lining
½" Steel plate
No. 12 gauge corrugated sheeting
grout
8" C.B. 24 lb
4'-2" o.c.
Section D-D
Section A-A
87'-6"
59'
Steel shell
18"φ drain (bronze)
24"φ By-pass (bronze)
Section B-B
25' Rad.
2' clear
Steel shell varies in thickness from 1" to ½"
Sym. about C.L.
½" steel shell
6"φ Well
Varies
Bottom 17'-2" (El. 2064.75)
Top 14'-10" (El. 2270)
Control Shaft
Emergency Shaft
Half Section C-C

FIG. 3—FOUNDATIONS of the shafts (shaded) were excavated and concreted from below before general shaft excavation was carried down to top of tunnel. Details of shaft lining are shown in various cross sections.

concrete which was poured on the outside of the shell after the third pass was complete. The pouring of the two heavy concrete foundation blocks on the inside of the steel shell in this area was delayed until after welding had been completed. Above El. 2,080 concrete was to be placed both inside and outside of the shell at the same time. In this area the finished weld was placed from the outside of the cylinder, using the step back procedure, and restraint was imposed by struts welded back to the excavation liners and by the cylindrical shape of the steel.

The steel lining in the main shafts alone involved 2.2 mi. of full-strength weld and 2.6 mi. of water-tight weld. To keep abreast of the other operations, two batteries of twelve welding machines each were set up at the ground surface. Each battery served two shafts. The leads to the welders in the shaft were sometimes 250 ft. long, but functioned satisfactorily, and the arrangement obviated the movement of machines as the gangs rotated. Air was pumped as necessary from the surface to ventilate the 3-ft. space between the steel shell and the excavation bracing, where the welders were at work.

Steel form system

Below El. 2,056, the erection of the two heavy foundation blocks inside the cylindrical steel shell made the use of a standard form impossible. Above this elevation, the uniform 2-ft. reinforced concrete wall inside the steel shell permitted the use of a cylindrical steel form 50-ft. in diameter and 16 ft. 8 in. high. This height corresponded to two lifts on the steel plate, hence the construction joint was always at a uniform location with regard to the horizontal weld on succeeding lifts. This had to be considered carefully because of the restricted space in which the welders worked between the plate and the outside mat of reinforcing bars above El. 2,080. At designated points recesses were left in the 2-ft. lining to accommodate struts which will be installed later to brace the cylinder gate structure.

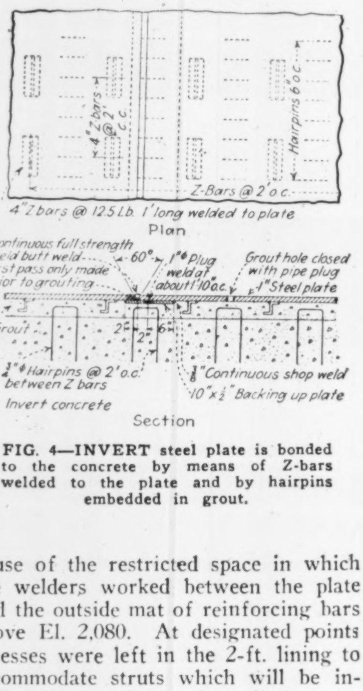

Hairpins 6" o.c.
4" Z bars @ 2" c.c.
Z-Bars @ 2' o.c.
4" Z bars @ 12.5 Lb. 1' long welded to plate
Plan
Continuous full strength field butt weld. First pass only made prior to grouting
60°
1"φ Plug weld at about 1'-10" o.c.
Grout hole closed with pipe plug
1" Steel plate
Grout
¾"φ Hairpins @ 2' o.c. between Z bars
Invert concrete
⅜" Continuous shop weld
10"x½" Backing up plate
Section

FIG. 4—INVERT steel plate is bonded to the concrete by means of Z-bars welded to the plate and by hairpins embedded in grout.

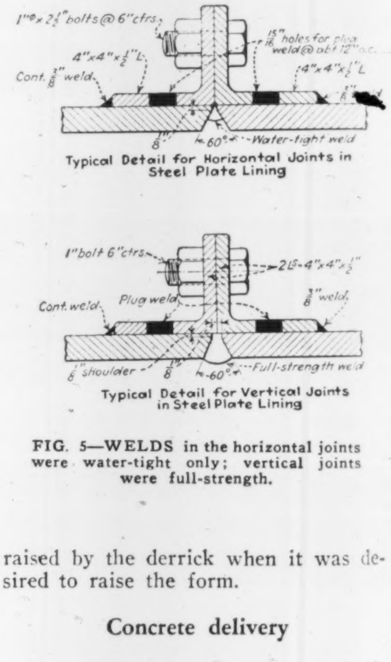

1"φ x 2½" bolts @ 6" ctrs.
4"x4"x½" L
1⅛" holes for plug weld @ abt 12" o.c.
Cont. ⅜" weld
4"x4"x½" L
60°
Water-tight weld
Typical Detail for Horizontal Joints in Steel Plate Lining
1" bolt 6" ctrs.
2Ls-4"x4"x½"
Cont. weld
Plug weld
⅜" weld
⅛" shoulder
60°
Full-strength weld
Typical Detail for Vertical Joints in Steel Plate Lining

FIG. 5—WELDS in the horizontal joints were water-tight only; vertical joints were full-strength.

The form was of steel and built in quarters so each quarter would fall within the 10-ton load limit of the guy derrick, if necessary. However, an ingenious arrangement in the field permitted the whole form to be raised at one time. Steel I-beams were cantilevered from concrete foundations at the surface to overhang the shaft at the quarter points. A four-part tackle was run from a block suspended from each I-beam to a block on the corresponding quarter of the form below. The four running ends of the cables reeving the four sets of blocks were joined to a common ring which was raised by the derrick when it was desired to raise the form.

Concrete delivery

An existing concrete plant a half-mile away and 200 ft. lower in elevation was selected as the cheapest source of concrete. Dump trucks capable of carrying two cu.yd. of mixed concrete (mixer capacity) were provided for transportation and proved very satisfactory. Loss of heat during cold weather gave some concern in advance, but experience showed concrete having a temperature of 73 deg. F. at the mixer had a temperature of 60 deg. at the form, even though air temperature was as low as 10 deg. below zero.

Concrete delivery from truck to form was accomplished with a 4-yd. bucket handled by derrick. This bucket was specially designed to meet the conditions (Fig. 2). It was equipped with a cylindrical upper body wide enough to receive concrete from the dump trucks without spillage, and it had a conical lower body with a 10-in. round outlet at the point. This outlet was closed by a 14-in iron sphere which could be raised by a hand winch on the operator's platform on top of the bucket. At the surface, the buckets rested on frames set in holes in the ground to permit the trucks to dump directly to them. At the form the charge was dumped by an operator who rode the bucket. Two buckets were available; one was being loaded while the other was in the shaft.

On each lift, concrete on the outside of the steel shell was raised simultaneously with that on the inside. Small hoppers located on top of the steel shell just above the level of the form were connected to elephant trunks leading to both portions of the pour. Concrete delivery to these hoppers at twelve points around the circumference of the big shaft presented a problem which was solved by the construction of a "whirligig" chute (Fig. 2). A hopper was suspended by cables from the cantilever beams at the surface so that it hung in the center of the shaft just above the form. Below this hopper was a framework carrying two chutes 180 deg. apart, leading from the bottom of the hopper to the circumference of the shaft. The chute frame work was swiveled to the bottom of the hopper and could be pulled around by one man on the form for delivery of concrete to any desired point on the circumference. The central location of the hopper in the shaft gave a standard target for the derrick operator to hit and the small size of the bottom of the bucket, compared to the size of the top of the hopper, made spotting easy. A ball valve in the bottom of the hopper, similar to that in the bucket, controlled delivery to the chutes as desired. The entire rig was removed from the shaft after each pour and set up for the pour in the next shaft.

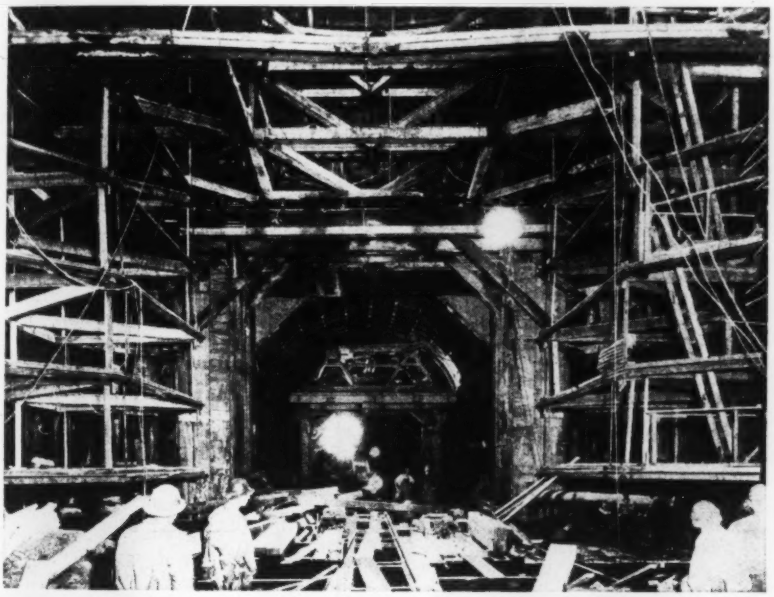


FIG. 6—BRACING SYSTEM of one of the main shaft foundations. The invert and part of the wall concrete has been placed.

Shafts 2, 3 and 4 were driven from a natural ground surface elevation equal to the top of the finished dam. Ground surface at No. 1 was 37 ft. lower than the top of the dam so it became necessary to build this lining up above ground as shown in Fig. 1. The same steel form was used inside and the outside was formed with wood held together with steel bands.

Future work

The inside tower, gates, operating machinery and building for the main shafts will not be installed until after the closure of the dam and the diversion of the Missouri River through the tunnels. This is because the operation of the cylinder gates requires the pondage of about 50 ft. of water, whereas it is desired to minimize pondage during the first twelve months of closure. Provision is made for unwatering the necessary portions of the tunnel and shaft while the subsequent work is going on. Meanwhile the river will be controlled by two tractor-leaf gates now being installed in each tunnel and operated through the rectangular emergency control shaft upstream of the main control shaft. Fig. 1 shows the four buildings located over the emergency shafts which will house the operating machinery.

The lining of the main control shafts was done by the army engineers with government plant and hired labor. Lt.-Col. T. B. Larkin, C. of E., is the district engineer supervising the work; Major Clark Kittrell, is in charge of the operations division and the writer is directly in charge of tunnel work.

Plans for the entire Fort Peck Project are prepared in the Kansas City Office of the Missouri River Division, under the supervision of Col. R. C. Moore, division engineer.

Illinois Water Men Discuss Flood and Air-Conditioning

FLOODS, filter maintenance, and air-conditioning problems were the main topics discussed at the Springfield meeting of the Illinois section of the American Water Works Association April 29 and 30.

W. H. Lovejoy, superintendent of filtration, Louisville, Ky., outlined the methods used when operating the river pumping station of the Louisville Water Co. for 12 days with water 54 in. over the floor of the station. Steam was furnished from boilers on a barge floated along the lee side of the pumping station. The hose lines first used to carry steam burst and were replaced by 1½-in. pipe.

C. M. Roos, superintendent of the Cairo Water Co., described the flood conditions in southern Illinois and especially the precautions taken against sand boils in Cairo. H. A. Safford, assistant sanitary engineer, Illinois State Department of Health, spoke of the seven discontinued water services in 1,000 sq. mi. of southern Illinois flooded area.

Loran D. Gayton, city engineer, Chicago, outlined air-conditioning water requirements in the Chicago loop district. A total refrigerating capacity of 11,865 tons was reported last September in the 398 air conditioning installations. At two gallons per minute per ton of refrigeration 34 m.g.d. of water would be required. Flow measurements of the maximum demand on a hot, dry July day gave 65 m.g.d. for the whole Loop area; a reduction to 39 m.g.d. was observed in September.

So far as Loop sewers, which were installed 75 years ago, are concerned, C. D. Hill in 1911 reported that they should be five times the existing capacity to care for ordinary storm runoff. Nothing has been done in the last 25 years. Last summer the flow from the air conditioning installations on clear, hot days flooded basements. Unless cooling towers, evaporative condensers or other devices are installed a new sewer system will have to be built.

Newly elected officers of the section are: Frank C. Amsbary, Jr., chairman; Ray Crozier, vice-chairman, and W. D. Gerber, Urbana, secretary-treasurer.

Demand for Cooling Water at Wichita Exceeds Underground Supply

Experience of last summer indicates that underground supply is inadequate for existing drafts in business districts—Returning water to ground raises temperature in nearby wells

WHILE there is sufficient groundwater in the Arkansas valley at Wichita, Kan., for the purpose of cooling homes sufficient quantities do not exist for multi-story business buildings as proved by experience of last summer. Most of the office buildings pump from wells under them and the groundwater all but disappeared in a few locations. P. L. Brockway, city engineer, Wichita, in a paper on the subject presented at a recent meeting of the Kansas Engineering Society gave results of an inquiry from the users of air-conditioning equipment as now operating in his city. The following notes are taken from this paper.

A 10-story modern office building covering 10,000 sq.ft. reports that a number of individual tenants have installed air-conditioning units. One occupying 900 sq.ft. of floor space used water as follows: May 29 to July 10, 120,000 gal.; July 10 to Aug. 10, 312,000 gal.; Aug. 10 to Sept. 10, 202,000 gal.; Sept. 10 to Oct. 12, 38,000 gal. Doctors' operating rooms, 250 to 300 sq.ft. in area, use 70 to 100 gal. per hr. Expanding the 900 ft. space to the whole building area for the July 10—Aug 10 period one gets 1,100,000 gal. per day or the equivalent of 4,785,000 gal. per acre.

Groundwater conditions

The Arkansas valley has a fairly coarse water-bearing sand 20 to 25 ft. deep over an empervious shale. It will supply 800,000 to 1,000,000 gal. per day from wells with not less than 500-ft. spacing in all directions, equivalent to 150,000 gal. per acre. Such water bearing strata are automatic in limitation. The draw-down cone to the well reduces the remaining depth of filtration into the well as ground water flows from greater distances.

Another report on cooling-water requirements gives the following information: In precooling of 21,000, sq.ft. of floor space to 80 deg. F. by circulutating coils, 50 g.p.m. was used. The water temperature was 60 to 65 deg. Refrigerating compressors used 80 g.p.m. and raised the water temperature from 60 deg. to 80 deg. Throttling the condensers to 40 g.p.m. raised the water temperature to 100 deg., indicating no apparent loss in heat efficiency but more power used in that particular equipment. A log of the well from which the 130 g.p.m. was pumped giving water depths indicates a drawdown of 8 to 9 ft. and the ultimate capacity of the well at 200,000 gal. per day, enough to air-condition an average of 1½ stories.

Three 12-in. wells 21 ft. deep in a theater basement produced 15,000 gal. per hr. for 12 hours to cool 558,400 cu.ft. of space to from 76 to 78 deg. During a 12-hr. period when 1,800,000 gal. were pumped the water temperature was raised from 68 to 82 deg.

Another building, principally offices, cools 200,000 cu.ft. on the average. The temperature was maintained at 78 deg. The pump capacity is 100 g.p.m. and water temperature rose from 66 to 75 deg. The building is 200 ft. downstream from the theater named and the water supply became limited.

A department store on an area of 21,000 sq.ft., 300 ft. farther downstream from the office building, has a top floor tea room of 18,700 sq.ft. supplied with three pumps having a capacity of 134 g.p.m. running part time. The basement and first floor are cooled with pumps furnishing 135 g.p.m. operating 11 hours per day, a total volume of 100,000 gal. per day. Return water temperature is 87 deg. There was not sufficient water to keep two floors and basement cool continuously.

The three buildings which use jointly 2 m.g.d. are close enough to effect their mutual groundwater supply. Fully cooled for one-half the time the three buildings would use 6 m.g.d.

Homes cooling 1,000 sq.ft. of floor space and operating full time and with a density of five homes per acre on the above basis will consume 10,000 gal. per day or 50,000 gal. per acre, which is within the limits of the groundwater yield in the Arkansas valley but not in most other Southwest localities.

Recirculation of no value

Return of the well water to the ground to conserve the supply is considered a doubtful expedient and of no value if universally adopted. It is practised however. In one case where the supply ran low a new well was sunk apparently puncturing the outflow from a return well from another building. Water came out at 92 deg. After being pumped for 60 hours it was still 90 deg. and then abandoned. The department store mentioned above returns 55 g.p.m. into the same well from which it pumps 135 g.p.m. As a result, the ordinary 68-deg. temperatures of the groundwater was raised to 74 deg. On the other hand the office building using only 100 g.p.m. discharged it all into a well 70 ft. from the producing well. The temperature was raised only 1 deg.

Conclusions are that recirculation through the ground will not be successful for large consumers or for consumers having neighbors using the same method. At residences return to the ground may well be through lawn sprays or sub-irrigation drain tile.

City's Liability To Consulting Engineer

THE NEW YORK statute requiring cities to advertise for bids for contracts does not apply to the engagement of professional services, such as those of an engineer employed to investigate the water rates charged city consumers and to testify before the Public Service Commission. However, the city must have the power to engage a consulting engineer before it can be held liable for the payment of his services, said the United States Court of Appeals in a recent decision involving the liability of the city of Utica to pay an engineer who had performed satisfactory services as a consulting engineer at the city's request. Where a private-party contract would be enforceable if a consulting engineer acted in reliance on the promise to pay, a municipal corporation is not so bound, as a legal proposition. The consulting engineer by acting at the city's request cannot raise the presumption that the employer had implied power to pay for his professional services and expenses under the doctrine of ratification. The approval of the city officials as agents of the municipal corporation in retaining the engineer created no legal obligation to pay him when the city lacked power to employ him for this type of services. Potts vs. City of Utica, 86 F (2) 616., U. S. Cir. Ct. App., Nov. 30, 1936.

Canal Lining Completed On Colorado Aqueduct

COMPLETION of lining of the 63 mi. of canal on the Colorado River Aqueduct was reported April 14 by the Metropolitan Water District of Southern California. This work involved covering more than 500 acres of canal surface with an 8 in. concrete lining.

Canal sections are all located in comparatively flat areas of the desert between the Colorado River and the Hayfield pumping plant, 40 mi. east of Indio. The canals are 55 ft. wide at the top, 20 ft. wide at the bottom, and are 12 ft. deep.

Steel Pipe 11½ Ft. in Diameter Welded by Improved Methods

On Colorado River aqueduct, steel 31/32 in. thick welded in place in the trench—Inner enamel coating spun on—Shotcrete protects outer surface—Advances in shop and field practice

IN PREPARATION for completion of the Colorado River aqueduct, now scheduled for the winter of 1938-39, construction has been under way for some time on the distribution system which the Metropolitan Water District of Southern California is building for delivery of aqueduct water to member cities. It is to be remembered that the 242-mile main aqueduct from the Colorado River has its western terminus in Cajalco reservoir. Some 150 miles of distribution lines will be required to convey the water to the thirteen cities of the district, located on the coastal plain between Cajalco and the sea. These distribution lines are the equivalent of a major water system in themselves, including a large mileage of tunnels, precast concrete pipe up to $12\frac{1}{2}$ ft. in diameter and steel pipe in diameters up to $11\frac{1}{2}$ ft.

The entire distribution system will be gravity flow, made possible by the height of Cajalco reservoir whose level ultimately will be at El. 1405. From Cajalco to the north and then to the west a total of about 45 miles brings the main line to Morris reservoir in San Gabriel Canyon. This will be a secondary storage point from which the distribution mains will continue west and south.

Not all of the 150 miles is under construction at the present time; exact location of certain parts of the distribution system will be determined by later developments in the plan for disposing of the water. The 60 miles now under contract includes 35 miles of concrete pipe, 15 miles of tunnel and 10 miles of steel pipe. The steel pipe begins 2 miles north of Cajalco reservoir and extends 54,530 ft. in a northerly direction between portions of the line in which precast concrete pipe are used. Because of the large diameter of the steel line particular interest attaches to methods of fabrication in the shop, placement in the trench and in welding metal as thick as 31/32 in. under trench conditions, that is, where the pipe cannot be rotated during the welding process. On Jan. 1 about 27,000 ft. of pipe had been welded in the trench and in the progress of this work various improvements were made which constitute advances over previous methods. The following describes details of the processes employed in shop and field.

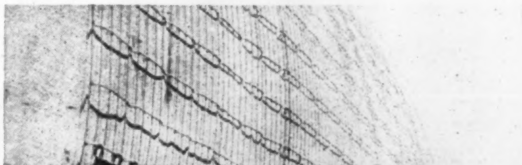


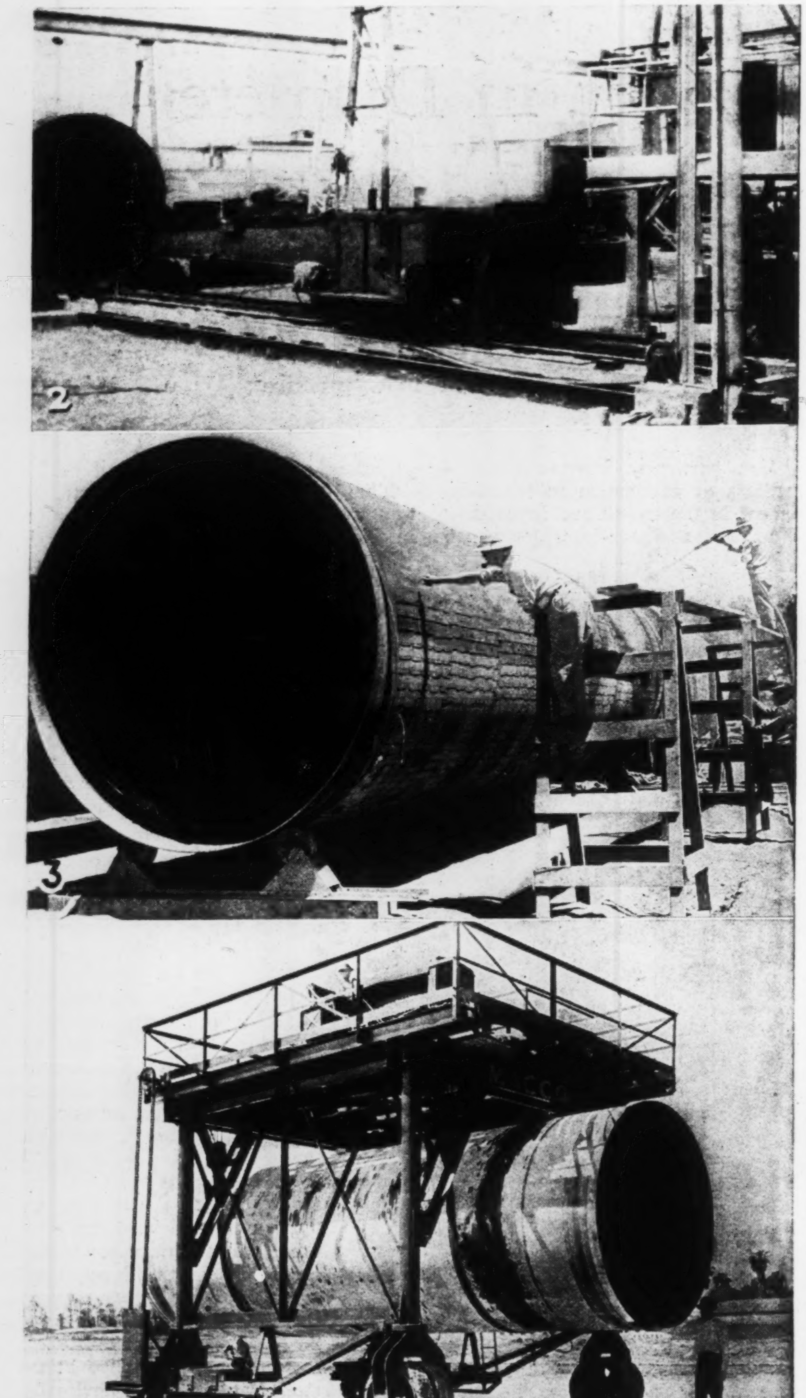
Fig. 1—IN PLACING REINFORCING mesh, uniform tension is put in the wires by a toggle-operated device which holds the mesh while it is being fastened permanently.

The 10-mile portion of the distribution system to the north of Cajalco in which the large steel pipe is used, traverses a region where soil conditions for part of the length are bad. In places high alkali content shows severe corrosive tendency. For about a mile the water table is 2 ft. above the pipe grade and with sulphur present in the ground water, the danger of electrolysis became a factor in design. Because of these conditions two types of coating for the pipe were chosen. Type *A* has an outer protective coating of shotcrete; type *B* has the same shotcrete coating but before this is applied an insulating coating of enamel similar to that used on the pipe interior is put on. Type *B*, designed to resist high corrosive qualities in the soil, will be used on about 20 per cent of the 10-mile length.

The steel pipe sections are all 33 ft. 4 in. in length, diameters range from 10 ft. 4 in. to $11\frac{1}{2}$ ft. except on the bridge across the Santa Ana River where pipe of 9 ft. 8 in.-diameter is used. The thickness varies, according to the head, from $\frac{17}{32}$ to $\frac{31}{32}$ in. Correspondingly the weight ranges from 18 to 28 tons per section. The enamel coating is applied at the steel plant in Los Angeles but the shotcrete coating, which adds about 5 tons to the weight of each section, is put on in a yard at Arlington about 60 miles east of Los Angeles near the field operations.

Shop welding practice

Each 33-ft. 4-in. section is made up of four steel plates rolled to the proper curve and requiring only a single longitudinal weld in each plate to form a cylinder of the pipe diameter. The completed section is made up by putting together four of these cylinders and



Figs. 2, 3, 4—**IN THE ARLINGTON YARD** the enamel tank (top) is mounted on a track so that its cantilever arm can be extended into the rotating pipe section to paint the interior. The exterior is coated with shotcrete (middle picture). Thickness of the coat is checked by an inspector as the work progresses. Pipe is moved about the yard by a gantry (lower picture) operated by a gasoline engine mounted on the top.

welding the three circumferential joints. In assembling a section, longitudinal welds are staggered. Circumferential welds are made in a large automatic electric welding machine which completes the weld, even in the 31/32-in. thickness, with a single pass.

Two types of mounting are used for the welding machines: for longitudinal seams the welding equipment is on a carriage which moves lengthwise of the pipe as the weld progresses; a larger machine, used for making the circumferential welds, is stationary and the pipe is rotated as the weld progresses. Both welding machines operate on top of the pipe.

The adjoining edges of the plates to be welded are beveled so the molten metal flows in a *V*-shaped groove filled in advance with a flux. The flux is a silicious material applied in a powdered form resembling ground glass. The heat of the electric current, fusing the flux, forms a covering over the molten metal closely resembling glass in texture and brittleness. This glass-like covering is so brittle it is easily broken off with a hammer after the weld has cooled. The automatic welding machines work at about 40 volts and use a current of 1,100 or 1,200 amp. In the longitudinal welds a pair of plates with a *V* groove similar to that in the joint itself are tack welded at the end of the joint where welding starts, thus affording a few inches for the welding operation to get well under way before reaching the joint in the pipe. Test coupons, attached at the end of the longitudinal weld, are taken every 800 lin. ft. of weld.

Bell ends are shaped cold in all metal thicknesses; the two manufacturers who share this contract use different methods in forming them. One plant rolls the bell shapes and the other forms them with a hydraulic press. In the latter the desired shaping is done by successively pressing portions of the circumference under a hydraulic jack. Between applications of the jack shoe, whose length is about 12 in., the pipe is rotated so that one-half of the shoe length will work on new metal for each advance around the circumference.

All pipes with metal thicknesses exceeding $\frac{5}{8}$ in. are annealed, after welding, at temperatures of 1,100 deg. F. after which they are cooled slowly. The next process is a hydrostatic test for which special equipment has been developed in plants of both manufacturers. To simplify the test and avoid the large quantities of water that would be required to fill sections of such large diameter, the testing machines are equipped with a rigidly constructed cylinder which occupies most of the space within the section to be tested, thus requiring only enough water to fill the annular space around it and inside the section. Hydrostatic pressures are used in the test which will produce stresses in the pipe metal exceeding by 60 per cent the working stress to which the pipe will be subjected in service (13,500 lb. per sq.in.). The test pressures used are equal to 44,000 times the metal thickness in inches divided by the diameter of the pipe section in inches.

After the hydraulic test the sections are taken to the small enclosure in which sandblast treatment, using steel shot, is applied to the inside of all sections, and for type *B* pipe to the outside as well as to the inside.

Applying enamel

Coal tar pitch enamel is applied at the plant to the inside of the pipe section by a centrifugal process that makes use of a spinning machine. Difficulty was experienced at first in getting a satisfactory bond between enamel and pipe. This was because of the small volume of hot enamel with respect to the large volume of thick cold metal. To overcome this difficulty, the expedient of preheating the pipe to 175 or 200 deg. F. was tried, and this has proved successful in all respects. The preheating is done by a row of gas jets on the outside of the pipe section as it is rotated on the spinning machine. By rotating the section slowly (3 r.p.m.) while the gas flame is applied to its exterior, the heating occurs uniformly and after about 15 to 20 min. the temperature of the steel (determined by electrical pyrometer) is raised to 190 deg. F.

Before the enamel is applied a primer coat of cut-back coal tar is put on with an air spray, inside of all pipes and outside of pipes on which type *B* coating is used. It has been found necessary for this primer to dry for 24 hours before putting on the enamel. Priming in damp air is not permitted and where the enameling is delayed for 72 hours after the primer coat is put on, repriming is required to avoid risk resultant from loss of bonding quality in the primer. Contrary to what might be supposed, the process of heating the pipe with a direct gas flame as described does not harm the priming coat.

The interior coating of enamel is limited by specifications to a minimum of $\frac{1}{16}$ and a maximum of $\frac{1}{8}$ in.; 3/32 in. was selected as the ideal thickness and a 1/32-in. tolerance each was was allowed. About 1,000 lb. of enamel is required for the interior of each section. During application the pipe is rotated at a peripheral speed of 1,100 ft. per min.

Enamel is heated in gas fired kettles whose capacity is sufficient to completely coat the inside or outside of one pipe section. Projecting from the bottom of the movable kettle is a 35-ft. boom containing a spout through which hot enamel is discharged. The boom is lagged to prevent escape of heat and carries electric heating elements so temperature within the boom can be maintained the same as in the kettle, i.e., 475 deg. F. To make certain of uniform flow, enamel is circulated by pump continuously through the boom in a return circuit when no enamel is being delivered.

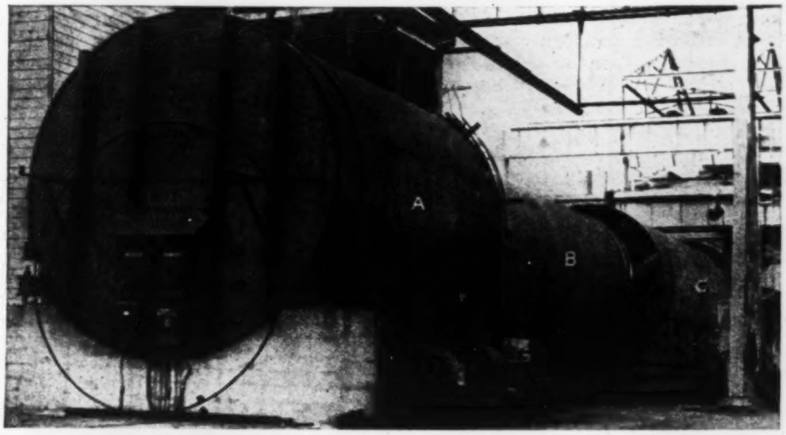


Fig. 5—PRESSURE TESTING EQUIPMENT: *A* is water storage tank. *B* is drum to occupy internal space in *C*, the section to be tested.

At the forward end of the boom a valve can be opened so the enamel will discharge into a 12-in weir parallel to the pipe center line. Thus when flow of the enamel is begun at one end of the pipe section to be coated, application is made in a band or stream 12 in. wide. The speed of advance of the boom is regulated with respect to the rate of pipe rotation so that two revolutions occur while the weir is advancing a distance equal to the width of the stream. In other words, the coating is applied in two layers. A speed of 37 r.p.m. gives a peripheral speed of 1,100 ft. per min. with which excellent results are reported. A peripheral speed of 800 ft. per min., which was tried at first, did not give the desired spreading. About 4 min. is required for transit through a pipe section of the weir delivering the enamel. After application has been completed the valve at the boom end is closed by remote control, the boom is withdrawn and the pipe is rotated for a few minutes more at full speed and then at reduced speed, while water jets are played on the outside to hasten chilling and hardening of the enamel.

The sections which are to receive an external coating of enamel are transferred, while the pipe is still hot, to adjoining rolls where the external enamel is applied as the section is rotated slowly. A 12-in. length of the pipe at each end is left without enamel covering, both inside and outside, so there will be no coating of the metal to interfere with the field joint. These unprotected zones at the pipe ends, however, are coated later in the field.

When the enamel lining has cooled sufficiently an inspector with felt pads over his shoes walks through the section testing the enamel thickness. To do this he first cuts away the enamel by the twist of a knife blade to expose the steel at a spot where a test is to be made. A steel gage measures the thickness and the measurement in thousandths of an inch is marked with chalk at the point where the test is made. The small pits made for testing are later filled by using a soldering iron to melt a small piece of enamel into the small crater dug by the inspector's knife. A test for "holidays" in the lining is made with a steel brush on which a high voltage is maintained to show a spark discharge at any point where there is a break in the enamel. By lightly sweeping the pipe interior with this brush inspection can be made very quickly and even the smallest break in the enamel, such as would be formed by a small air bubble, instantly becomes apparent. The soldering iron is used to correct any defects indicated with chalk by the inspector. As a final treatment at the steel plant the exterior of each pipe section is given a coating of whitewash to minimize the effect of the sun's rays during the 60-mile trip to the yard where the shotcrete coating is applied.

A shotcrete coating

From the steel plant pipe sections are delivered by rail on flat cars to the yard at Arlington on the outskirts of Riverside. Here a gantry (Fig. 4) lifts the section off the car and deposits it in the yard to await its outer coating. Before the shotcrete is aplied a steel reinforcing is wrapped around the pipe section and drawn up taut by a toggle device (Fig. 1) which puts uniform tension in the wires. This reinforcing is a 2x4-in. mesh of 12-gage wire, crimped so that "chairs" keep the plane of the mesh about $\frac{3}{8}$ in. away from the metal. The type *B* sections with their outer enamel coating must have their shotcrete treatment while the tar is cold and consequently hard. As a result the shift that coats the Type B sections works from 4 a.m. to 12 noon to avoid the latter part of the day when the enamel would be softened by the heat of the sun.

For application of the shotcrete the pipe section is placed on rollers contacting the pipe at the ends where the metal is left bare for jointing purposes.

Burlap is used to prevent the shotcrete from adhering to bare metal at the pipe ends. In applying the shotcrete it is desirable to make application on alternate sides so as not to unbalance the section unduly. The shotcrete is applied as shown in Fig. 3 and the thickness is immediately tested by the inspector. If additional material is required the thin section is marked and an additional layer is put on promptly. The rebound amounts to about 35 per cent of the material used and necessitates care in avoiding accumulations on top of the pipe. As soon after the application as possible a workman brushes off the top of the pipe section to remove rebound particles that are certain to land there.

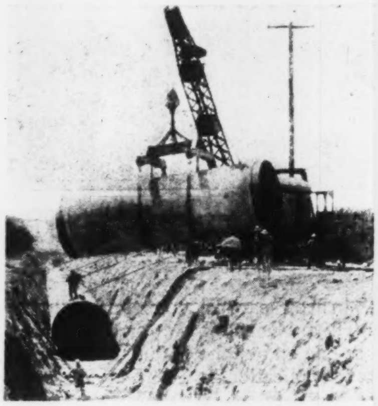


Fig. 6—PLACING A SECTION of pipe in the trench. The bell end (at left) is kept lower so the top of the joint can be entered first.

Shotcrete is applied to a finished thickness of $\frac{3}{4}$ in. It was originally intended to apply a $1\frac{1}{2}$-in. coating on the type *B* pipe. However, experience with the $\frac{3}{4}$-in. thickness was entirely satisfactory as to density, imperviousness and flexibility, and it was felt that flexibility might be sacrified with the thicker coating, so the $\frac{3}{4}$-in. thickness has been used for both types. The shotcrete is cured by applying a coat of coal tar cut-back sealing compound.

Storage space in the Arlington yard was laid out with a view to coating eight sections of pipe per day. Using a single nozzle for applying shotcrete takes 1 to $1\frac{1}{2}$ hours to coat a section.

Handling pipe sections

Before spinning in the inside enamel coating, the sections are stiffened internally at each end with circular rings of I-beam section. Immediately after spinning a section it is further reinforced with a pair of stiffening struts set at right angles in each end of the section to help retain the circular shape in transit and during the application of shotcrete. These struts remain in place until the pipe goes into the trench. In the yard at Arlington finished pipe sections are loaded on trailers by the gentry and hauled to a position beside the trench within reach of the whirley boom. By means of a double yoke, with a pair of steel bands from each crossbeam, the section is lifted from the trailer and lowered into the trench.

While being lowered the bell end is kept about 2 ft. below the level of the spigot end (Fig. 6). Thus the bell end makes contact first at the crown with the pipe section in place in the trench. This contact is made and the bell is slid over the spigot $3\frac{1}{2}$ in. at the crown while the forward end of the section is still about a foot high. In this position the crown of the bell, fully entered, is welded with two or three passes of metal for a length of about 6 in. This constitutes a "hinge" to hold the crown of the arch in place while the section is slowly lowered to final position. Because of this hinge fastening at the crown, as the section is lowered to final position the weight is effective in seating the section firmly and forcing the joint home. If the weld is cracked in this process it is cut out and rewelded after seating.

Before a section is lowered into the trench, chalk marks are placed at intervals on the inner face of the bell 4 in. from the end, thus providing a line from which to check the specified $3\frac{1}{2}$-in. overlap in joints. Jacks and struts are used to bring the section to true round; the vertical strut is jacked about $\frac{1}{2}$ in. high to allow for deformation from the weight of backfill.

Welding field joints

When a joint is fully entered ready for welding it is tacked with welds 4 or 5 in. long spaced as required. This is done to prevent any tendency to creep as welding progresses around the circumference. The tack welding is done by one man on the inside and two on the outside.

Completion of the weld involves a number of passes varying with the thickness of the metal, as stated in the accompanying table. With the seven passes for the thickest metal, the $11\frac{1}{2}$-ft. pipe requires 40 man-hours per joint or the equivalent of one man's time for a full week on the inside and outside of a single joint. With a crew of about 40 welders, joints in the trench are completed, inside and outside, at the rate of eight sections per day.

The district has set up exacting requirements for welders which provide that each man shall be capable of meeting the qualification test specified in par. W-451 of the Petroleum Institute-Amer. Soc. M.E. code for unfired pressure vessels. Each applicant is given a thorough examination and a practical test including the following welds: single lap vertical, single lap overhead, double butt vertical and double butt overhead. Tests of these specimen welds made in the laboratory constitute part of the applicant's rating. All welds, in shop and field, are done electrically. In the field current is supplied by portable motor-generator sets equipped for remote voltage control. The welder sets the control for any voltage he prefers from 40 to 80; the amperage is about 250.

Finishing field joints

After welding has been completed, unprotected metal on the inside is simply and quickly covered by putting on a primer coat and afterward applying enamel by hand. On the outside several requirements have to be met. For type *B* coating the metal is first sandblasted with portable equipment moved along the edge of the trench, then a primer coat is swabbed on, followed by two coats of enamel. Wire mesh then is fastened in place, and a coating of shotcrete is applied which is thoroughly sprinkled and finally is covered with a sealing compound. By this treatment every endeavor is made to give the joints as effective a protection as the remainder of the pipe receives. For type *A* coating a similar procedure is followed, except that sandblasting and enameling are omitted.

Before the external finish is put on, field joints are tested hydrostatically through four $\frac{1}{4}$-in. holes taped through each bell into the annular space between the bell and the spigot. This space is sealed off by the inside and outside welds. These test holes are put in at the steel plant at the quarter points on vertical and horizontal diameters. After the holes are threaded a plug is put in each one until the test is made. The test consists in applying pressure to soapy water into the annular space. Testing equipment includes connections for each of the four test holes which are all served from a common reservoir in the testing machine. Water is allowed to trickle in until the annular space is full, then it is put under a pressure of 80 lb. per sq-in. which is alowed to remain for 5 min. while the inside and outside welds are inspected for soap bubbles. So effective has the jointing been that thus far only three flaws have been found in 900 joints.

Pass holes 3 in. in diameter are made in every fourth section at the top of the pipe. These are tapped in before

SCHEDULE OF PASSES FOR METAL THICKNESS

Metal Thickness (inches)	No. of Passes
$\frac{17}{32}$ to $\frac{5}{8}$	Four
$\frac{21}{32}$ to $\frac{3}{4}$	Five
$\frac{25}{32}$ to $\frac{7}{8}$	Six
$\frac{29}{32}$ to $\frac{31}{32}$	Seven

the pipe leaves the shop and are used for admitting electric cords to serve the welders working inside. After the welding is completed these holes are pluged and given the same tar and shotcrete treatment as are the joints.

With work on the pipe completed the backfill is moved into the trench by a dragline and jetted into place around the pipe. A crew of three men using a 1-in. jet under moderately high pressure work on alternate sides of the pipe to balance the thrust as the fill progresses. In this way compact placement is secured quickly and effectively.

The work is being done under contract for the Metropolitan Water District of Southern California, F. E. Weymouth, general manager and chief engineer; James Munn, general superintendent. Julian Hinds is assistant chief engineer, R. B. Diemer is division engineer on the distribution system, H. R. Bolton, resident engineer in charge of pipe lines, and Charles Goetz, inspector in charge of field welding. K. Q. Volk is resident engineer on this contract. The general contractor for the entire schedule is the Western Pipe & Steel Co. Subcontracts are held by the Consolidated Steel Corp. for half of the pipe manufacture, by the Macco Constructing Co. for the shotcrete coating, by Dan Teters Co. for concrete work, and by the Morrison-Knudsen Co. for excavation and backfill.

New Brunswick Sewage Plant Aids Raritan River Clean-up

Major source of pollution will be eliminated by 9 m.g.d. chemical precipitation type disposal plant —sludge digested and mechanically dewatered.

By Daniel M. Vail

*Designing and Supervising Engineer
New Brunswick, N. J.*

Abatement of pollution in the Raritan River, one of New Jersey's major waterways, was brought a step closer to realization in April when a 9 m.g.d. chemical-precipitation type sewage disposal plant was placed in operation at New Brunswick. The new treatment plant, employing sedimentation aided by chemical coagulation, is expected to provide 75 per cent reduction of suspended solids. Sludge will be digested, dewatered on vacuum filters, and then used for filling lowlands. The plant will be formally opened by the city with ceremonies in June.

Initiation of the plans for the New Brunswick plant followed a court order obtained by the New Jersey state department of health directing all municipalities in the Raritan River valley to cease pollution of the stream. Designs were completed in the fall of 1935 (see *ENR* Mar. 26, 1936, p. 448) and work was started shortly thereafter with the financial aid of a PWA grant covering 45 per cent of the cost. The cost of the entire project, including additional sewers and a pumping station, was $500,000.

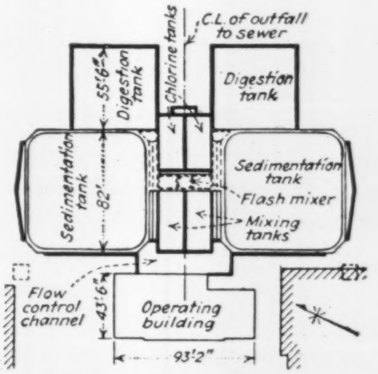


FIG. 2—COMPACT LAYOUT of the 9 m.g.d. New Brunswick sewage disposal plant

The plant and collecting sewers are

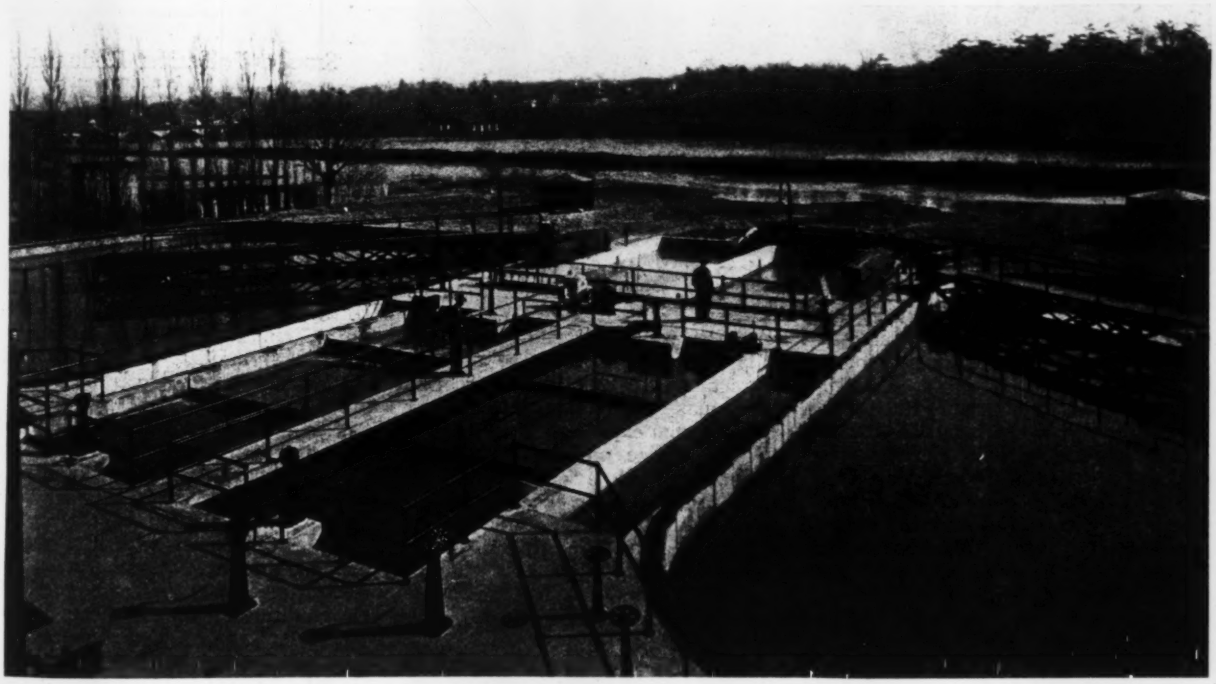


FIG. 1—FLOCCULATION AND CHLORINATION tanks (in the center) are flanked on either side by square clarifier units. The gas domes of the underground digestion tanks are in the background.

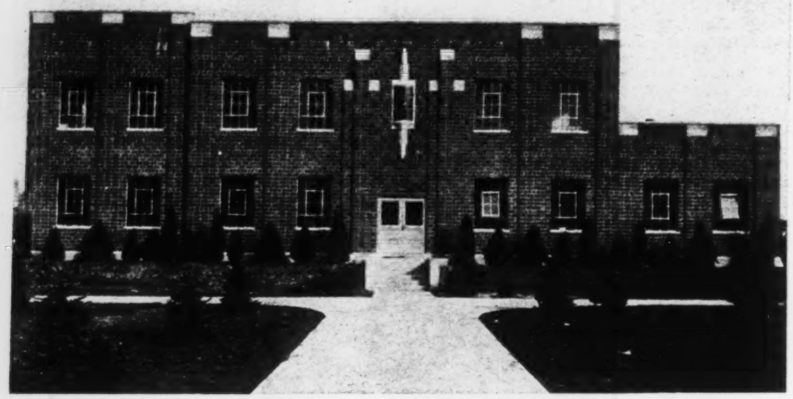


FIG. 2—OPERATING BUILDING of the disposal plant which is situated on a street near the center of the city. Hidden behind this structure, on the banks of the river, are the sedimentation and digestion tanks.

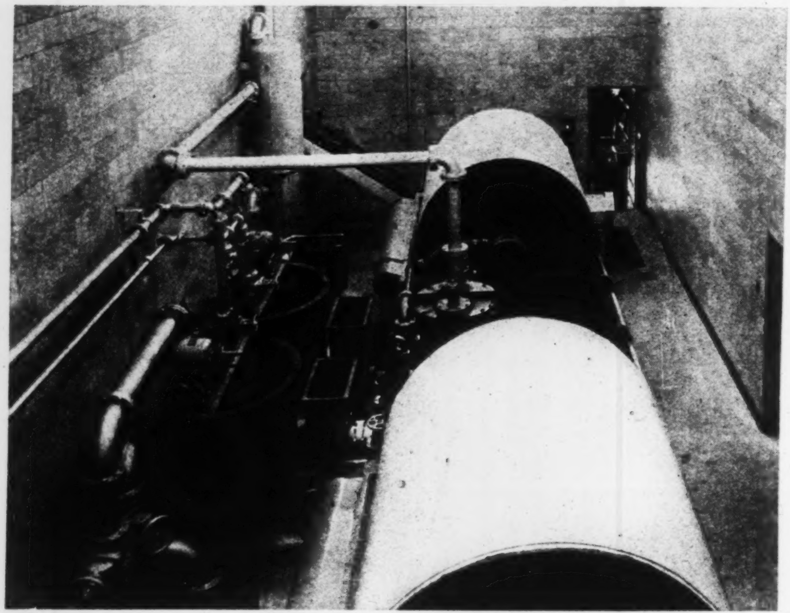


FIG. 4—Sludge dewatering equipment showing the string-discharge vacuum filters and the chemical conditioning tanks.

designed for an ultimate flow of 9 m.g.d. but the present flow does not exceed 6 m.g.d. The topography of the city is such that about 50 per cent of the sewage must be pumped for a distance of about 1½ miles. Sewage reaching the treatment plant first passes through a mechanically-cleaned bar screen having 1-in. openings. It is then pumped to a flash mixer where a coagulant and lime are added. Immediately after leaving this mixing chamber the sewage goes into flocculation basins equipped with paddles which move slowly at right angles to the flow. Following a 20 min. flocculating period the sewage is settled in square clarifiers which are provided with mechanical scrapers and scum removers. The two tanks are each 82 ft. square and 11½ ft. deep. The clarified effluent is sterilized with chlorine before it enters the river.

At these points of application different types of chemicals will be added at different times in the year in order to obtain maximum treatment efficiency with minimum expense.

Settled sludge will be digested in two underground tanks, each 55½ ft. square and 17 ft. deep. Digested sludge will be conditioned with ferric chloride and lime prior to dewatering on string-discharge vacuum filters.

Chemical distribution

Chemical distribution equipment in the plant includes: (1) chlorinators, which are used for pre-chlorination, for manufacturing chlorinated copperas, and for post chlorination; and (2) dry feeders and solution feeders which are so arranged that coagulants and lime may be fed to the sewage flow at various points in the plant. Control devices for the entire plant are centralized in one room. Pump motors and the driving mechanism of all the outside equipment are controlled from this point.

All of the equipment is protected with overload devices, signal lights and alarms; by this arrangement the work of the operators is minimized and there is small danger of faulty or improper operation.

Plant aids river clean-up

Following closely upon the installation of the Perth Amboy mechanical chemical treatment works near the mouth of the Raritan River, the New Brunswick plant, located 10 miles upstream, will be an important factor in reducing the pollutional load emanating from a number of industrial establishments and a tributary population of about 38,000 people. The present flow of sewage is approximately 6 m.g.d., of which 1½ m.g.d. is trade waste of various kinds.

The plant has been operated for about a month and a half under trial and test conditions and present indications are that it will function at higher efficiency than originally anticipated, using this type of chemical treatment.

The New Brunswick plant was designed and its construction supervised by the engineering department of the city. Willem Rudolfs was the consulting engineer on the project.

◆

Smoke Pollution Reduced Over New York City

Air pollution in New York City has been reduced more than 65 per cent since 1931, according to Prof. H. C. Frank of Stevens Technical Institute, Hoboken, N. J., reporting on the results of the air pollution survey carried on in the metropolitan district by Stevens Institute in cooperation with the U. S. Weather Bureau since 1931. Prof. Frank's report was delivered at the March meeting of the Industrial Smoke Abatement Association of Hudson County.

This Association was organized last year to cooperate with William G. Christy, Smoke Abatement Engineer of Hudson County.

The annual election of officers was held in connection with the regular monthly meeting. A. W. Akins, was elected president; first vice-president, G. H. Binder; second vice-president, W. L. E. Keuffel; third vice-president, J. S. Hollowell; fourth vice-president, G. A. Ambro; secretary, H. Yunker; treasurer, J. Gerhard.

Letters to the Editor

Skyscraper Roost

Sir—High up on the southern facade of the Sun Life Building, Montreal, highest building of the city, two fierce peregrine falcons or "duck hawks" are nesting, as they do normally on the faces of inaccessible cliffs. Montreal orthinologists discovered the birds after weeks of ceaseless vigil from the roofs and windows of neighboring buildings, following a clue obtained last year when one feather of these rare birds was found on the roof of the building. The head office building of the Sun Life Insurance Co. is just over 400 ft. high, and its architectural treatment is such that the birds have been able to use a cranny similar to those which they usually select in natural surroundings. It is believed that this is the first record of a skycraper being used for this illicit purpose.

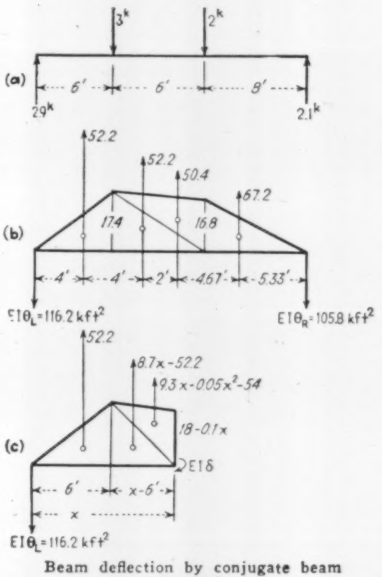
ROBERT F. LEGGET,
Kingston, Ontario, Canada.
26th April 1937.

Determining Beam Deflections

Sir—The letter by A. W. Fischer, (*ENR*, Feb. 18, 1937, p. 274) regarding a previous article entitled, "Determining Beam Deflections Without Integrating," suggests a comment or two with respect to the relative merits of the methods discussed. Fundamentally the "Shear Area Method" is the method of the conjugate beam. The basic philosophy here involved is simple and is one which may be applied to any *three* of the successive integrations involved in moving mathematically from the load equation to the deflection equation. Five separate diagrams may be constructed corresponding to the equations for load, shear, moment, slope, and deflection, which result from these successive integrations. The first three—load, shear and moment—involve very simple and well understood relationships, indispensable in every-day study of structures.

When the same type of relations existing between these three diagrams are applied to the shear, moment, and slope equations and diagrams, the procedure has been called the "shear area" method. When applied to the moment, slope and deflection relationships the method is generally known as the "conjugate beam method."

From the historic point of view it seems that both of these methods are one and fall properly under the heading of the conjugate beam method. Any one of the curves in the series of five may be considered as a conjugate beam. May I point out here that the use of the moment diagram as a conjugate beam for the purpose of finding deflections is more simple and direct than the use of the shear diagram (which is the method of the shear area). This arises out of the fact that the moment diagram used as a conjugate beam is placed in equilibrium by slope and deflection values which constitute the unknowns of the problem. When the shear diagram is used as a conjugate beam, the unknowns are moments and slopes. The finding of the deflection requires an additional operation. In addition, when dealing with variable moment of inertia, the procedure is much more involved when the shear area forms the basis of the computation than is found to be the case when the solution arises from the use of the moment diagram.



Beam deflection by conjugate beam method

It appears that the shear area method can only compete in the field of concentrated loads and constant moment of inertia. Under all other circumstances it seems that the treatment of the moment diagram as a conjugate beam yields a more speedy solution.

To be sure, as with all other methods, it is assumed that one is familiar with the legitimate short cuts normally developed through constant use. The writer has used the conjugate beam method for years in a wide variety of cases involving every type of structure from the simple beam up through complex indeterminate frames with variable moment of inertia, and under many circumstances finds it a method of high utility for current use.

The accompanying example illustrates the application to the simple case of finding the position and amount of maximum deflection in the beam shown in (a). The moment diagram is equilibrated by the addition of $EI\Theta$ reactions, (diagram *b*), the values for which are obtained through $\Sigma M = 0$ about either end. At the point of maximum $EI\delta$ the value of $EI\Theta$ is zero. Therefore the conjugate beam of diagram *b* must be cut at such a point *x* as will provide a moment area above the axis equal to $EI\Theta_L$ the left reaction. (See diagram *c*).

Since $\Sigma F = 0$

$$52.2 + 8.7X - 52.2 + 9.3X - 0.05X^2 - 54 = 116.2$$

$$18X - 0.05X^2 = 170.2$$

$$X^2 - 360X = -3404$$

$$X = 180 \pm 170.3 = 9.7 \text{ ft.}$$

$\Sigma M = 0$ about the left end yields an equation in which EI is the only unknown and from which

$$EI\delta_{max} = 708.3 \text{ kip ft.}^3$$

For beams involving a variable moment of inertia the procedure is equally direct and involves only a division of all ordinates in the diagrams *b* and *c* by the corresponding ordinates of *I*. That is to say when *I* does not vary the conjugate beam may be formed from the moment diagram; but if *I* varies the M/I diagram must form the foundation for the conjugate beam. In cases of extreme complexity of variation of *I*, the M/I diagram may be laid out to scale and the whole operation performed graphically.

F. B. FARQUHARSON
Assistant Professor of Civil Engineering,
University of Washington
Seattle, Wash.
March 19, 1937

Need for a Public Works Program

Sir—In a recent editorial you advocate ending or drastically cutting WPA and PWA relief activities.

One of the most serious problems confronting society today is discrimination against employment of persons over forty years of age. A committee appointed by Bronx County Chapter, New York State Society of Professional Engineers, is now studying recommendations for support of national legislation to reduce unemployment of trained and qualified persons. Among the subjects under discussion is "An elastic public works program to take up the slack in private industry."

A permanent, planned public works program is a necessary part of the present day social order. Furthermore, there are many worthwhile projects, the planning and execution of which can be handled by experienced engineers over forty years of age.

WALTER G. FEDERLEIN
New York, N. Y.
May 10, 1937

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Editorial offices at 330 West 42nd Street, New York

May 20, 1937

Backed by Logic

CURRENT ARGUMENTS concerning the power to be developed at Bonneville Dam center around who is to generate and distribute the power. Of three bills now before Congress, two would place generation in the hands of the army engineers and would place distribution and sale in the hands of a civilian administrator. The third bill places both in the hands of the administrator. The argument for putting the army engineers in charge of power generation finds its origin in the fiction back of the legislation authorizing construction of the dam, namely, that the dam is primarily for navigation and hence its power plant and locks should be under the jurisdiction of the army engineers. But everyone knows that the main purpose in building the dam is to generate power. Hence, when Secretary Ickes argues, as he did before a House committee last week, that both generation and distribution be placed in the hands of the power administrator, logic is on his side. The army engineers should not be put into the power generating business just to keep alive the fiction that Bonneville is primarily a navigation dam.

No Misgivings

THE LAKE BEHIND BOULDER DAM has filled to the point where the continuous output of power is assured. On June 1 the government expects to begin to supply firm power to the power contractors. While the lake has been filling a number of earthquakes have been recorded in the region around the dam, a fact that has given rise to speculation as to whether or not they are caused by the weight of water accumulated behind the dam. That there might be settlement due to the great weight of water, was anticipated. Months ago, before the lake began to fill, the U. S. Geological Survey undertook to set accurate benchmarks from which settlement of the region adjoining Lake Mead could be checked. Longer ago, the engineers who made the final designs for Boulder Dam took the possibility of earthquakes into consideration. As a result, the approved design was ultra conservative; the structure has ample stability as a gravity-section dam and in addition is arched in plan, forming a great concrete wedge between the canyon walls. It is conceivable that a major earthquake might open up some of the construction joints in this massive structure, but that it should fail completely even under such adverse conditions is beyond conception. The engineers who designed and built Boulder Dam can listen to the current reports of earthquakes with no misgivings.

Mixed Statistics

STATISTICS OF HIGHWAYS have existed for only about a dozen years. Today they cover mileage, general type of improvement and expenditures on federal and state systems in some detail; for the remaining five-sixths of the highways only a rough count exists. Voluminous as are the tabulations published in this issue they are at best a puzzle picture with many of the pieces missing. These conclusions are emphasized not as a criticism of the past but as a justification of the inventory and traffic surveys now in progress in some forty states. With these figures available in a year or two student of highway transport will possess the facts with which to approximate a balance sheet of public roads investment and revenue. This is not now possible and the highway official suffers a definite disadvantage in convincing legislatures and the public of future planning needs. With the figures summarized on a preceding page the opposition has most of the facts it needs to prove large expenditure on selected systems and to justify its demands for redistribution. The highway engineer needs figures for the income side of the ledger and these he does not have. The present road inventory is his way out.

A Signpost

WHEN THOMAS H. MACDONALD some weeks ago in speaking to the state highway officials prophesied a new road planning and roadbuilding age some conservative minds were not prepared to see eye to eye with him. It was argued that our present road system is good enough and that we should learn to use it well before we go farther. But those who have to deal with the hard facts of present-day transportation problems are conscious of the new need in very realistic fashion. The New York State Planning Board, for example, recently expressed its conviction that the freeway principle must find recognition in the planning and building of major trunklines. Its statement is a plain signpost to progress, for two reasons among others: first, that at present our huge road investment is made in part ineffective by the interference of roadside occupancies, and second, that traffic conflicts at intersections further reduce its transportation efficiency. Everything indicates that these losses will increase, and that our major roads will steadily deteriorate in efficiency unless the new principle is embodied in them. Since freeway construction will to a large extent mean new road locations, a job of vast size appears to be ahead. Every state that has large density of population and traffic has already come to realize that concretely, as is illustrated by New England, whose newer projects are partly of freeway type.

Voice Opinions Now

STREAM POLLUTION LEGISLATION may be enacted during the present session of the Congress and the time for engineers and other interested parties to give expression to their views is now. The Vinson bill (HR-2711) was passed by the House of Representatives on April 21 and is now pending before the Senate (Barkley bill S-702). From several viewpoints this measure seems to be the best of those proposed. In contrast to other mandatory pollution bills which have been introduced (Lonergan, Pfeifer and Spence) the Barkley-Vinson bill recognizes local responsibility and jurisdiction of the states, and provides for close cooperation with industry, federal and state governments. It would make the U. S. Public Health Service—a department that has demonstrated its ability to work harmoniously through state and local officials—the technical coordinating and supervisory agency to administer the act. To stimulate the construction of treatment works the bill would provide 33⅓ per cent grants-in-aid and loans to states and muncipalities and loans to industry. Engineering and construction work would be handled by local government units and industry in the customary manner through their established technical staffs or usual consulting engineers. Properly administered, the Barkley-Vinson bill presents a sound and orderly approach to pollution abatement.

Exit Upstream Engineering

THE PROCEEDINGS of the Upstream Engineering Conference of last fall were sent to Congress by the President on May 12 with a few very general recommendations. Among them he said: "With respect to some problems, drainage basins must be treated as a whole, both headwaters and main channel of any river system being brought into an integrated program of regulation." There will be general agreement with that statement, but it appears a bit ironical that the President should make it in connection with the report of a conference that he called for the express purpose of demonstrating that the upstream part of any drainage basin has peculiar engineering problems that set it apart. Despite the purpose back of the call, the conference papers make it quite clear that the problems of flood control, water and soil conservation change little as one progresses from the headwaters down to the river's mouth, and all are closely interrelated. The President's message should put an end to the idea that there is any such thing as "upstream engineering."

Traditions Discarded

THERE IS FOOD FOR THOUGHT in the proposal of stockholders of the Old Colony Railroad that its lines be divorced from the New Haven system and reestablished as an independent system free to develop new sources of traffic and new connections with other transportation systems. The stockholders' committee suggests using a fleet of sea-train ships or car ferries to give the Old Colony direct connections from New Bedford, Newport and Fall River to New York terminals of such roads as the Jersey Central, Erie and B. & O. Thus the Old Colony, serving a highly industrialized area in eastern Massachusetts, would be in a position to compete with the New Haven-Pennsylvania systems for traffic to and from the West and South.

This proposal is put forward by a group of able business men. It cannot but raise question as to whether such a group, free of railroad traditions and inhibitions, might not introduce innovations that would have a far-reaching effect on railroad transportation. Much New England freight now moves through the New York area on car floats. As long as the cars must be loaded on and taken off of floats it may well be that the water movement could be extended economically. Then too the possibilities of the motor vehicle as an adjunct of rail transportation, especially in terminal areas, have not been fully explored. Similarly, container cars may have possibilities for much wider use than is now general, and there are some who see in the container car a step in the direction of smaller cars such as are so widely used on European railroads.

The railroads of the country generally are handicapped by inability to raise new capital easily and cheaply, also by deep-rooted conservatism. But the conservatism of the railroads has not acted as a check on all progress, as is witnessed by the widespread introduction of air conditioning of passenger cars, the increasing number of light-weight, high-speed trains, and the lowering of passenger fares. A few of the more progressive spirits among railroad managers pioneered in introducing these innovations, and the public response was so favorable that competing lines were compelled to follow suit. Similarly in freight handling, the conservatives long opposed store-door-delivery and pick-up, but customer demand and competition makes its universal acceptance a foregone conclusion. Other needed innovations should follow in like manner. It may be some will come through the introduction of new blood into railroad management in the reorganization of railroad systems such as the New Haven and Van Sweringen lines.

Vibrated Pavement

DELAY IN DEVELOPING VIBRATION as an aid in improving the quality of pavement concrete is noticeable. At least five years ago tests made by the Bureau of Public Roads indicated that vibration made possible a denser and stronger concrete and one that cost less for materials. Succeeding trials of vibration in actual roadbuilding in half a dozen states confirmed the test conclusions, though they also indicated that some problems in equipment and production remained to be worked out. Thereafter, however, development of the new process virtually ceased except as a promotional activity by commercial interests, until about a year ago, when the Bureau of Public Roads again took up the test road studies it had laid aside in 1931.

What happened to vibration in roadbuilding after its auspicious beginning? The resumed studies by the Bureau of Public Roads reported recently to the Concrete Institute show clearly that all the promises of the earlier tests are still good. Actual practice in concrete paving has not shown vibration to be impracticable; instead such isolated special operations as are recorded clearly indicate the contrary. The reason does not lie largely in the failure of vibration in concreting operations other than paving. In mass concrete work vibration has made steady if not rapid progress; in building construction it has advanced more slowly; in paving it is at a standstill. Why is it not making progress in paving?

Any answer is speculative. One cynical road engineer has said that vibration squeezes the air out and the roadbuilder wishes the air to remain so that he will be paid for it. A sounder answer is that dry concrete is harder to handle and mileage production is cut down. Many other reasons are advanced, but they all boil down to the inevitable resistance to perfecting a new concreting technique by special equipment and processes.

Such obstacles have never in the past been permitted to stand in the way of technical progress in concrete paving; they should now be overcome as they have always been. Vibration offers a useful means of improving pavement concrete and highway engineers cannot afford to overlook any resort that will accomplish improvement. Instead it should be pursued and made to give its help; the Bureau of Public Roads has set the example and state highway departments should now take on leadership.

CURRENT NEWS

Public Works Less In Interior Bill

House appropriations committee reduces budget figures for Interior Department public works

Completing its consideration of 1938 appropriation bills for the federal establishment, the House committee on appropriations on May 11 reported favorably the Interior Department Appropriation Bill, carrying funds for all activities of the department during the fiscal year ending June 30, 1938.

As reported, the bill carries a total of $115,871,265, nearly $6,000,000 less than approved by the Bureau of the Budget. This net reduction represents total decreases of $13,250,400 as compared with budget recommendations, and increases in certain items totalling $7,284,550.

By far the largest reduction made by the committee is in that part of the public works program supervised by the Interior Department; these reductions amount in all to $11,300,400.

The larger items in the bill are:

	Appropriation Approved	Reduction from Budget
Bureau of Reclamation (total)	$40,981,600	$4,200,000
Boulder Canyon....	2,550,000	450,000
All American Canal.	1,500,000	....
Central Valley......	12,500,000	2,500,000
Grand Coulee......	13,000,000	1,000,000
Other projects (From Reclamation Fund)	10,666,600	240,000
National Park Service:		
Blue Ridge Parkway and Natchez Trace..	3,000,000	2,000,000
Bureau of Indian Affairs:		
Irrigation and drainage	3,261,998	4,000
Roads and bridges..	2,760,000	260,000
Geological Survey.....	2,787,000	40,000

Increases over budget allowances were granted by the committee in a few instances. The largest increase was $4,241,500, bringing to $14,483,000 the appropriation for stimulating vocational education in the states by allotments to the states under the George-Deen Act. An additional $1,161,380 was granted for the maintenance of public buildings in the District of Columbia, bringing this total to $7,137,280.

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Firm Power Generation Starts At Boulder Dam

Boulder Dam on June 1 will settle into its regular permanent routine of power production, and from that date forward all Boulder Dam power purchase contracts will be in full force. Notices have been sent to the cities of Los Angeles, Burbank, Glendale, and Pasadena, Calif., that, in accordance with contracts with those cities, 1,250,000,000 kw.-hr. of energy per year will be ready for delivery on June 1 at a rate of payment of 1.63 mills per kilowatt-hour.

Court Refuses to Enjoin PWA Power Loan

Actions brought in the District of Columbia courts by two utility companies—the Alabama Power Company and the Iowa City Light and Power Company—seeking to enjoin Public Works Administration allotments for municipal power construction in a number of municipalities were dismissed May 10 by the District of Columbia Court of Appeals. The decision did not involve the question of PWA's constitutionality, but confined itself to charges of unlawful competition brought by the two companies. It was held that neither of these held exclusive franchises and that the prospective competition was therefore not unlawful. From the opinion:

"The fact that, in furnishing the funds which will enable the municipalities to engage in such competition, the Administrator may have exceeded his authority, or may have acted under an unconstitutional statute, does not affect the situation. The thing which affects the plaintiffs is the competition, and that is lawful."

The decision places these cases in line for consideration by the U. S. Supreme Court early next fall as a test case upon which will depend the fate of over 50 similar PWA allotments on which litigation is now pending.

The municipalities concerned in the suits are Decatur, Sheffield, Tuscumbia, Guntersville, Hartselle, and Russellville, Alabama, and Iowa City, Iowa.

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New Jersey Federal Aid Cut May Be Tested in Court

The Joint Appropriations Committee of the New Jersey legislature has instructed the counsel for the state highway department to confer with state attorney-general Wilentz on the advisability of bringing litigation to determine the legality of the penalty of one-third of its federal-aid apportionment recently made against the state by the Federal Bureau of Public Roads because of increased diversion of gasoline tax money to other than the highway purposes for which it was intended.

The committee contends that the provision of the Hayden-Cartwright act which provides that states which increase their tax diversions shall be penalized one-third of their normal allotment was improperly applied to New Jersey. The committee maintains that New Jersey is now using more money for highway construction than at the time of the passage of the federal aid act in 1934.

The Federal Bureau of Public Roads announced its intention of reducing New Jersey's allotment when the legislature diverted $7,918,000 of highway funds. Gov. Hoffman thereupon vetoed the bill but the legislature overrode the veto. (*ENR*, April 29, 1937, p. 647).

TVA Injunction Set Aside

Circuit Court overrules Gore Injunction against expansion of power distribution facilities

By a unanimous vote of the three justices, the U. S. Circuit Court of Appeals for the Sixth Circuit, sitting at Covington, Ky., on May 14 set aside the injunction against further expansion of Tennessee Valley Authority power activities issued December 22, 1936, by Judge Gore of the U. S. District Court for the Eastern District of Tennessee.

The Circuit Court decision was not concerned with the merits of the suit brought against TVA by a group of southeastern utilities, but merely reviewed the decision of the lower court on several preliminary points, notably (1) whether the complainants should be protected by an injunction pending trial of the issue, and (2) whether the lower court had erred in refusing to dismiss the case as requested by government attorneys. On the second point the court divided 2-1, the majority holding that the case should go to trial in the District Court. Judge Moorman, in a dissenting opinion, wrote:

"I agree to the setting aside of the injunction, not on the grounds stated . . ., . . . but for the reason that in my opinion the bill does not state a case for judicial decision. The suit is an attack upon the aims and purposes of TVA as expressed in its 'power program.' Its purpose is to obtain a decree invalidating the program, not as an act or acts about to be done, but in its plans and purposes. This tenders an abstract issue only . . . I am of the opinion, therefore, the bill should be dismissed, and I dissent from the holding that it should not."

The suit was originally filed May 2 1936, by nineteen utility companies operating in the southeastern area. The number has since been reduced to 17 by decisions of U. S. District Courts in Georgia and Alabama eliminating the Georgia Power Company and the Alabama Power Company because of previous cases within the respective districts decided in favor of TVA.

Administration lawyers regard the decision as one of the most important yet handed down in the legal battle between TVA and the utility industry and believe that the Authority is now free to extend its lines and solicit new customers. Immediately after the decision was announced Representative John E. Rankin of Mississippi renewed his demand for the impeachment of Judge Gore, "who issued this injunction against TVA in flagrant violation of law."

Gilbertsville dam approved

The decision came as the Senate was debating the second deficiency bill, con-

Wide World photo

NEW MINT AT SAN FRANCISCO

THE SOUTH face of the new $1,000,000 San Francisco Mint, now nearing completion. A picture of the framework, showing the earthquake resistant design, was shown in *ENR*, Sept 3, 1936, p. 349.

taining appropriations for continuing TVA activities during the coming fiscal year. The principal bone of contention was a brief committee amendment which, although it does not increase the size of the appropriation, does authorize the beginning of construction on the Gilbertsville Dam, located on the Tennessee River only a few miles above its mouth. Total expenditures for this project, over a period of six or seven years, are estimated at $112,000,000. A number of Senators attacked the amendment with charges that this large expenditure is out of proportion to flood control expenditures in other sections of the country, and that the TVA set-up, which does not require local contributions, does not conform to the flood control policy adopted in the omnibus flood control act of 1936. The amendment was adopted, however, by a vote of 46 to 29, and the bill subsequently was sent to conference carrying a total appropriation of $40,166,270 plus authorization of future contracts for equipment to the extent of $4,000,000.

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Bids Asked for Water System For New York World's Fair

The New York World's Fair Corp. has announced it will open bids May 26 on a water distribution system at the Flushing Meadows site of the 1939 New York World's Fair. Contractors for the work must be prequalified.

The work will consist of furnishing and placing a water distribution system comprising about 35,600 ft. of steel, cast iron, asbestos cement, and temporary steel water mains 6 to 20 in. in diameter.

Piles 40 to 60-ft. in length which will be required for part of the work will be furnished by the corporation and driven by the contractor.

The work is required to be completed within 150 days after the contract has been awarded to the successful bidder.

Engineers Ask 35 Ft. Channel For St. Lawrence River

A dredging program to provide a 35-ft. ship channel in the St. Lawrence river between Montreal and Quebec and to raise water levels in Montreal Harbor has been recommended to the Canadian department of transport by the board of departmental engineers appointed to study the water-level in the river.

The $14,856,000 program was suggested as the result of a study of low water conditions in Montreal harbor which has been under way since January, 1934. The program involves an expenditure of $13,521,000 for widening the present ship channel with a grade depth of 35 ft. In addition, new channels would be dredged at Sorel and Three Rivers at a cost of $825,000 and $500,000.

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College Seniors Speak At Society Meeting

A selected group of senior engineering students spoke before a recent meeting of the Structural Engineers Association of Northern California. Brief talks were made by twelve students from the University of California, eight from Stanford University, and three from the University of Santa Clara. Each student was invited to ask one question in the course of his talk; at the conclusion of each talk the chairman selected a member to answer the question from the floor. In sharp contrast to a similar meeting last year, there were no questions this year on where to find employment.

This meeting was the second example of a plan initiated last year by the Association's professional training committee. This committee has been organized for the purpose of maintaining closer contact between students at engineering schools and practicing engineers. The present plan is intended as a move in that direction.

Power Policy Change Opposed by Ickes

Power Policy Committee attacks Army control of Bonneville powerhouses and FPC control of rates

Expressing vigorous opposition to proposed amendments to the Smith power policy bill (*ENR*, Feb. 25, 1937, p. 312), Secretary Ickes, speaking on behalf of the National Power Policy Committee before the Rivers and Harbors Committee of the House of Representatives May 10, defended the original form of the committee's recommendations of last February on the question of a policy for the administration of power generation and sale at Bonneville Dam.

A bill now before the Senate (*ENR*, April 15, 1937, p. 569) and proposed amendments to the Smith bill in the House would place control of the operation of the generation plant at Bonneville under the jurisdiction of the Army Engineers, leaving only transmission lines under the control of the civilian administrator. The original report of the Power Policy Committee recommended that the civilian administrator control both generation and distribution of power, leaving to the Army Engineers control of the navigation features of the dam. Last week Secretary Ickes reaffirmed the contention of the power committee that the generation and transmission of power are so closely linked that it is essential that they be under common management. "To put the installation and operation of the generating facilities under one branch of the government," he said, "and the construction and operation of the transmission lines under another . . . is to divide responsibility and invite trouble."

Uniformity of rates

The Secretary went on to defend the power committee's recommendation that the administrator be given authority to set rates uniform over the entire area of power sale or over prescribed transmission areas. He stated that a requirement that rates be proportioned to the transmission distance from the dam would narrowly restrict the market outlet for power and said that "It is unthinkable that the benefits of national expenditures . . . should be confined to a small area near the power house."

Control of rates

Referring to a recent report (*ENR*, May 6, 1937, p. 685) of the Federal Power Commission, which objected to the proposal that rates be set by the administrator rather than by the power commission, Secretary Ickes asserted again that, "the fixing of rates during the early years at least will depend largely upon informed judgment of potentially available markets which can be made only by a study at close range."

He admitted, however, that rates would properly be subject to review by the power commission, and, in connection with the commission's objection that the present bill gives it no clear authority to revise schedules submitted by the administrator, the Secretary suggested that the wording of the bill be changed to state definitely that "If any rate schedule submitted to the administrator is not approved by the Federal Power Commission, the Federal Power Commission may revise such schedules."

Centralized Agencies For Power Asked

Brookings report to Senate committee recommends federal power agencies be combined and regulated by FPC

With a Presidential message on power policies imminent, Senator Byrd of Virginia, chairman of the Select Committee on Investigation of the Executive Agencies of the Government, early this week released that part of the study made for the committee by the Brookings Institution relating to federal activities in the fields of power and of mineral resources. On the subject power the Committee recommends:

Centralization of all federal power activities, with a few minor exceptions, in either an expanded Federal Power Commission or a new Federal Power Administrator. Transfers would include administration over power licenses granted before 1920 (from the Departments of Interior, Agriculture, and War) and all lending agencies for power purposes (PWA, REA, EHFA). The new body would be the central agency for the collection of power statistics, would conduct research on power for itself and for other federal agencies, and would approve proposals for the development of federal power projects.

Discontinue the National Power Policy Committee and relieve the Federal Trade Commission of further investigations in the utility field.

Regarding power developments by the federal government, the report states:

"When these projects are completed, the power installations are to function as 'yardsticks' whereby the rates charged by private power companies can be measured. If the 'yardstick' theory is to be of any value in practice, there must obviously be a fair allocation of the part of the cost of each project to be charged to the installation of power facilities as against the part to be charged to improvement of navigation, flood control, irrigation, or a combination of these factors. This allocation should be made by an independent power authority, not by the constructing and operating agency, which may be tempted to manipulate its capital base for power purposes in order to make a good showing.

"Furthermore, the production of electric power by federal agencies should be subject to supervision by the same authority that is responsible for the regulation of private power companies, so that a unified national power policy can be evolved and needless duplication of existing plants and transmission lines avoided. . . .

"Where generating facilities are installed as part of a multiple purpose project, involving navigation, flood control, or irrigation in addition to power production, the Federal Power Commission should be given full authority to allocate the part of the cost of the project to be charged to the power installation, to fix rates based on this allocation that will make the power plant self-sustaining and self-liquidating, to regulate the sale of power, either directly to the consumers or at wholesale for redistribution, and to pass upon proposals for the extension of transmission lines.

"It is not considered advisable that the power agency, whether it is the present Federal Power Commission or the proposed Federal Power Administration, should undertake the operation of Government power plants itself. . . . There can be no effective check on government power activities if the supervisory organization is also the operating agency. Finally, regulation of private utility companies can hardly be performed satisfactorily by a body that is also engaged actively in the production and sale of electric power."

Labor Shortage Claimed In Baltimore

An acute shortage of skilled workers in the construction trades in Baltimore is found this month by the local office of the National Reemployment Service; existence of a shortage is denied by the building trades unions.

According to officials of the Reemployment Service, the office has a large number of applicants' names on file, but most of them are unskilled or semi-skilled workers. There has been an increasing shortage in bricklayers and stone masons, and it is becoming more difficult to get operators of mechanical construction equipment, carpenters, painters, plasterers, and structural iron and concrete workers.

The Baltimore Building Trades Council, on the other hand, asserts that the statements of the Reemployment Service are misleading. It contends that the inability to get skilled men is due to unwillingness on the part of contractors to pay union wages. It is claimed that contractors are offering wages considerably below the union scale when dealing with the National Reemployment Service.

SOCIETY CALENDAR

BUILDING OFFICIALS CONFERENCE OF AMERICA, national convention, Cleveland, Ohio, May 31–June 4.

AMERICAN WATER WORKS ASSOCIATION, annual convention, Buffalo, N. Y., June 7-12.

ENGINEERING INSTITUTE OF CANADA, semi-centennial celebration, Montreal and Ottawa, Canada, week of June 15.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer convention, Milwaukee, Wis., June 21-25.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, annual meeting, Cambridge, Mass., June 28-July 2.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, New York City, June 28–July 2.

NEW YORK STATE SEWAGE WORKS ASSOCIATION, spring meeting, Utica, N. Y., June 3-5.

PENNSYLVANIA SEWAGE WORKS, Annual conference, State College, Pa., June 21-23.

LICENSE EXAMINATIONS

NEW YORK: Examinations for registration of professional engineers and land surveyors will be given by the New York State Board of Examiners July 6, 7, and 8 at Albany, Buffalo, New York, and Syracuse. It is expected that assignments to these examinations will be limited to candidates who filed their applications before Jan. 1, 1937.

IOWA: Examinations for professional engineers June 8 and 9, and examinations for surveyors June 10 in the Senate Chamber at the State House, Des Moines, Iowa.

MICHIGAN: Examinations for architects at the University of Detroit and examinations for engineers and surveyors at the University of Detroit, the Michigan State College, the Michigan College of Mines, and at Ironwood, June 21-23. Information may be obtained from the Michigan State Board of Examiners, 306 Transportation Building, Detroit.

Little Wagner Act Passed In New York State

The New York state legislature has passed the Doyle-Neustein bill establishing a "Little Wagner Act" for New York State. The bill sets up a labor relations board which would exercise in regard to intrastate commerce in New York substantially the same functions which the National Labor Relations Board exercises in regard to interstate commerce under the federal Wagner Act.

The law provides that all employees in the state, with the exception of those already covered by the provisions of the national labor relations act or the federal railway labor act or employees of the state or its political subdivisions or charitable, educational or religious associations, shall have the right to organize and to bargain collectively. The board at the request of either the employees or the employer is empowered to call an election to determine what organization shall be the exclusive representative of the employees in bargaining with their employer.

A list of unfair labor practices is set up, and the Labor Relations Board is charged with the duty of enforcing them. These forbidden practices include spying upon employees, maintenance of black lists, formation or encouragement of company unions, use of yellow dog contracts, refusal to bargain collectively or to discuss grievances with representatives of employees, discrimination against an employee because of union activity or because of testimony given before the Board, or "to do any acts . . . which interfere with, restrain or coerce the employees in the exercise of the rights guaranteed."

First Paper Received In Welding Contest

The first paper in the $200,000 competition of the James S. Lincoln Arc Welding Foundation has been received from Robert S. Hale of Cincinnati.

The competition (*ENR*, Feb. 25, 1937, p. 320) is for papers dealing with the subject of arc welding as a primary process in manufacture, fabrication, or construction in eleven different major divisions of industry. A principal prize of $13,700 and other prizes ranging from $7,500 to $100 will be awarded. Prizes will be awarded in the structural group in four sub-classifications: buildings, bridges, houses and miscellaneous.

Papers submitted must either describe the redesign of an existing machine, structure, or building so that arc welding may be applied to its manufacture or present a design of a machine, structure or building not previously made. The description of the design must demonstrate how a useful result which was impractical with other methods of construction or could better be done by arc welding has been obtained in the design submitted in the contest.

Papers must be submitted by June 1, 1938. Information on the contest may be obtained from the James S. Lincoln Arc Welding Foundation, Box 5728, Cleveland, Ohio.

Public Power Body Formed In Province of Quebec

The Quebec legislature has passed a bill giving municipalities the right, under certain circumstances and subject to many restrictions, to municipalize electric services now provided by private companies. Further, the legislature passed a bill May 11 setting up a provincial hydro-electric authority.

Under the terms of this latter act, a "National Electricity Syndicate" is to be created, a body which is intended to develop electric generating plants and distributing systems in the province. The syndicate will be advanced an initial capital of $10,000,000 by the government.

Although the syndicate is referred to as a "National" body, its operations are confined to the province of Quebec.

Operations of the syndicate may take either of two forms. On the one hand, the government may advance to the syndicate the necessary funds for establishing such undertakings as it designates, and in that case projects constructed are the property of the province. This procedure is similar to that of the Ontario Hydro-Electric System.

An alternative plan calls for joint ownership by the government and by private interests. For this purpose, the government may grant capital stock to the syndicate and permit it to issue stock and debentures to secure the necessary funds. In such cases the undertakings and the profits are the property of the syndicate and the share holders. When the syndicate acts as a joint stock company and issues stock, 60 per cent of the stock must be allotted to the government in order to assure that control of the project remains with the province.

The act also permits the government to contribute up to 55 per cent of the cost of establishing an electric distribution system by any rural municipal corporation in the province.

It is expected that the first mode of operation will be used by the syndicate in the establishment of an electric system for the scattered Lake St. John district, and it is probable that the second method will be used in connection with future developments in the northwestern part of the province, where new mining developments are gradually building up a large potential power market.

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Bids Asked on Model Basin

The Navy has advertised for bids for a new model basin, replacing the present model basin in the Washington Navy Yard, to be constructed at Carderock, Md. The bids are to be opened about the middle of July, and plans and specifications will be ready to issue to bidders in about two weeks.

The basin, to be known as the David W. Taylor model basin, was authorized by an act of Congress on May 6, 1936, and the Naval Appropriation Act, signed by the President on April 27, 1937, appropriated funds for its construction. The Maryland site was selected because of its special suitability by reason of rock foundations, adequate water supply, and proximity to the design staff of the Navy Department.

Although the model basin is operated by the Navy Department, it is a national project, working for shipping and scientific interests throughout the United States. It is to a large extent self-liquidating because all work done for an individual or private company is carried out at the expense of the individual or company concerned.

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Chicago Water Revenue Bonds Bring High Price

Financial stability of the Chicago Water Department is indicated by the sale May 7 of $1,000,000 of 3½ per cent water revenue bonds at 105.183, one of the highest prices obtained from this type of paper Chicago has ever received. The bonds, which mature in 1949 and 1950, are not a direct obligation of the city but are serviced by revenue from water sales. The award was made to a syndicate of three firms operating in Chicago, Milwaukee, and New York, respectively. The money is to be used for extensions of the system.

This low price for money indicates the possibilities should the city go into the market for funds with which to build filters.

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Stringer Failure Causes Collapse of Formwork

Failure of the formwork for the roof of a reinforced concrete reservoir at Allentown, Pa., reported in our issue of May 6, p. 673, was due to failure of a stringer supporting pans of fresh concrete, according to M. G. Mansfield of the firm of Morris Knowles, Inc., engineers on the project.

The reservoir is being built by the Bureau of Water with the aid of the Public Works Administration. It is 564 ft. long, 282 ft. wide and 27 ft. deep. The roof slab was poured in 18 distinct operations or sections, 17 of which had already been completed, leaving one section, 60 by 131 ft., containing 283 cu. yd. of concrete, to be placed at the date of the accident, May 4. This pour, in addition to the section of roof slab, included the drop panels and the top haunches for the 18 columns supporting the section.

Fifty-seven batches of concrete, or about 57 cu. yd. had been poured over an area of 60 by 20 ft., when the forms collapsed under the wet concrete, due apparently to the failure of a stringer under the steel pans. Failure occurred without any warning, the men below the deck hearing a loud cracking noise just as the pans dropped. The first collapse occurred in the center of the section midway between the columns and spread in a funnel-shaped manner, probably due to a side thrust on the adjacent supports.

Inspection of the formwork failed to produce any evidence of faulty workmanship or negligence. It has not been possible to identify the stringer that failed first.

Monopoly Charged In Concrete Pipe

Federal Trade Commission charges five companies monopolize concrete pipe manuafcture in the seaboard area

Five companies manufacturing concrete pipe and other concrete products in the Eastern seaboard area, including Virginia, Maryland, and the District of Columbia, are charged with practices tending to create monopolies and restrain trade in a complaint issued by the Federal Trade Commission. The companies named in the complaint are: Lock Joint Pipe Co., East Orange, N. J.; Gray Concrete Pipe Co., Thomasville, N. C., and Baltimore and Hagerstown, Md.; Concrete Pipe & Products Co., Richmond, Va.; Mid-Atlantic Concrete Pipe Products Co., Norfolk, Va. and Dover, Del.; and the Arlington Concrete Pipe Corp., South Washington, Va. Various individual owners of shares in these companies are also named in the complaint.

All the respondents in the case except the Arlington Concrete Pipe Corp. are said by the Federal Trade Commission to have been in active competition with one another before May, 1934. Now, however, through their stock ownership in and their interlocking of officers and directors with the Arlington Co., designated in the complaint as being their subsidiary company, and through an alleged unlawful conspiracy, the companies are asserted no longer to be in competition.

The companies are charged with failure to submit to prospective customers bids competitive with one another and with the subsidiary corporation and with submitting bids to prospective customers through and in the name of the subsidiary Arlington Co. and with quoting prices through and in the name of the subsidiary at amounts below production cost. They are also charged with making disparaging representations concerning the financial standing and business of competitors.

The Arlington Concrete Pipe Co. is stated to have been organized by the other respondents, who are said to own all of its stock.

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Beautiful Bridges Prizes To be Awarded

For the ninth consecutive year, the American Institute of Steel Construction will award prizes to the most beautiful bridges built of steel in the United States. Photographs of all bridges to be submitted in the competition must be received by the Institute, 200 Madison Ave., New York, N. Y., not later than June 19. Announcement of the selections for this year will be made next month by a committee of architects and engineers appointed for the purpose.

There will be three prize winners selected from bridges of three different groups: Those costing less than $250,000, from $250,000 to $1,000,000, and those costing more than $1,000,000. Only bridges opened to traffic during the calendar year 1936 will be eligible to compete in the A.I.S.C. contest.

Washington Highlights

By Paul Wooton

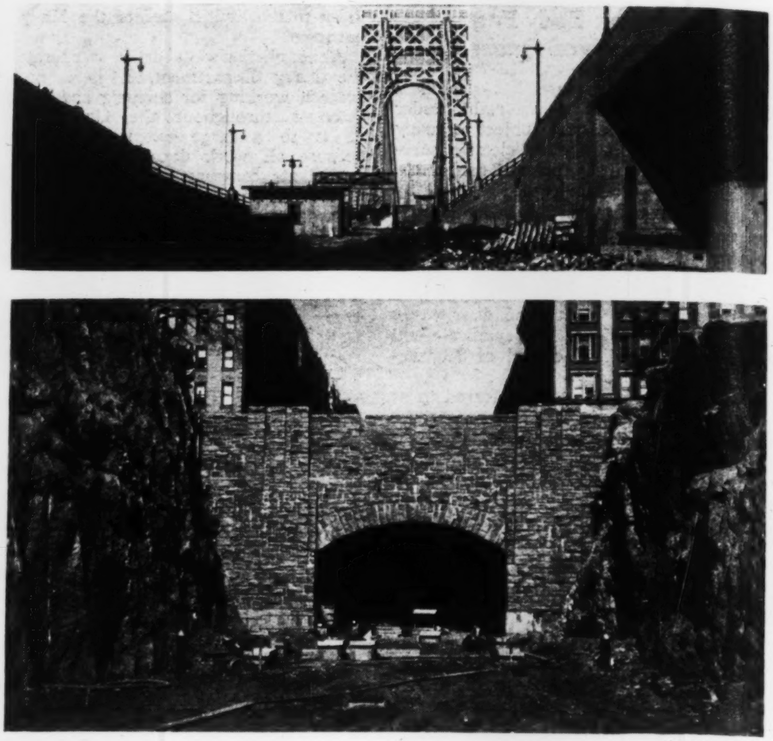
Plans for a permanent Civilian Conservation Corps were thrown out by the House on May 12 when it passed a bill continuing the CCC for two years with an enrollment of 315,000 at an annual cost of $350,000,000. House action also reduced the salary of Director Fechner from $12,000 to $10,000 and defeated a proposal to require civil service rating for civilian employees of the corps.

The battle against identical bidding goes on, with Administrator Ickes continuing to award contracts, in all cases of identical bids, to the manufacturer farthest distant from the point of delivery. On May 1 he awarded a $77,000 contract covering the reinforcing steel for the Yakima-Roza reclamation project in Washington to the Carnegie-Illinois Steel Co., which shipped from Duluth, in preference to the Bethlehem Steel Co., which submitted an identical bid for steel to be shipped from Seattle.

The Senate on May 17 passed a bill already approved by the House providing $25,000 to survey a hydroelectric power site at Cabinet Gorge, on the Clarks Fork of the Columbia River near the Idaho-Montana boundary. The study will investigate the feasibility of building a plant to supply cheap power for pumping and additional storage for an existing private reclamation development, and possibly for commercial power distribution in a nearby mining district. The development of additional land for reclamation, orginally included in the project, was deleted from the bill in view of a previous adverse report.

The appropriation committee of the House has been urged by Representative Whittington, chairman of the Flood Control Committee, to override the budget and increase to $50,000,000, the allowance for expenditure under the Omnibus Flood Control Act and to $45,000,000 expenditure under the Lower Mississippi (Overton) Act. The budget bureau has recommended $30,000,000 for the omnibus act and $22,500,000 for the Lower Mississippi Act. The omnibus act authorized the expenditure of $310,000,000 over a period of six years, while the Lower Mississippi Act authorized the expenditure of $272,000,000 over a like period.

President Roosevelt has submitted to Congress recommendations of the Upstream Engineering Conference held in Washington last September together with a letter recommending a broad approach to flood control and kindred legislation. Pointing out that flood control and water conservation problems are not confined to large rivers alone, the President stated that "With respect to some problems, drainage basins must be treated as a whole, both headwaters and main channels of any river system being brought into an integrated program of regulation." The message was phrased in general terms and recommended no immediate legislation. It is interpreted as an invitation to permit further study of the flood control problem without any immediate action except the routine appropriations which will permit the Corps of Engineers to proceed with certain urgently needed projects already authorized by Congress.



Mathieu Photo

NEW ROUTE TO THE BRIDGE

TUNNEL approach to the George Washington Bridge over the Hudson at New York City. The lower view shows the east end of the tunnel and above may be seen the Plaza approach to the bridge as seen looking west from the west end of the tunnel. Construction of this approach was postponed when the George Washington Bridge was built until such time as traffic necessitated it.

Second Flood Causes Trouble In Missouri Floodway

A secondary flood in the Mississippi River below Cairo caused trouble early in May at the head of the Birds Point-New Madrid Floodway. The levee at the head of the floodway was breached at several places during the highwater early this year and these crevasses had not been closed when the secondary flood came. This latter flood went eight feet over the low point in the crevasses, requiring prompt action to keep the floodway from being inundated a second time.

Evacuation ordered

On May 3, because of the rising waters, an evacuation of 3,000 residents was ordered, and the next day Maj. R. D. Burdick from the U. S. Engineer District Office declared an emergency, which resulted in reorganizing flood-relief forces from the WPA, State Highway Department, CCC, Red Cross and State Patrol. Some 6,000 men were recruited. A ring levee was thrown around the "bluehole" of the 1,000-ft. horseshoe section but a second loop levee was held, being reinforced by sand bags and timber bulkheading to ward off wave action. Cotton bale webbing was also used for this purpose. More than 600,000 bags were utilized. The total length of levee was about 8,000 ft. Equipment used included 6 draglines, 25 crawler tractors pulling 10 yd. trailers and several bulldozers.

Ruby Dam Bids Called Soon

Bids will be invited within a few weeks for the construction of Ruby dam, to store water on the Skagit river for use in hydroelectric plants owned by the city of Seattle, Wash. Funds now available total $4,500,000, of which PWA supplies 45 per cent and the city, through bonds already sold, 55 per cent.

The first step will include excavation of foundations and placing concrete from Elevation 1150 to about 1300, involving some 300,000 cubic yards of concrete. The second step, to be undertaken later, will bring the height to Elevation 1500, and the ultimate crest will be raised to Elevation 1725. Total concrete involved will approximate 2,300,000 cubic yards.

The contractor will be required to transport material from Diablo dam to the Ruby site, to build his own roads and camps, and to provide necessary equipment and facilities.

Work is near completion on surveys and diamond drilling (a total of 5500 feet of one-inch core drill) and clearing 110 acres. The reservoir site will not be cleared.

Sand and gravel of suitable quality are available about four miles upstream from the dam site.

A. S. Schulman Electric Co. of Chicago has started work on a $1,124,297 contract for construction of 560 steel transmission towers along a 116-mile line between Diablo and Seattle.

Brief News

The Soils Laboratory of the Muskingum Conservancy District is to be moved from Zanesville, Ohio, now that work in the district is nearing completion, and reestablished in Pittsburgh or Louisville to handle experimental work in connection with the Ohio River flood control program.

A Safety Lighting program is being put under way in Oregon with the illumination by sodium lights of twelve dangerous intersections on the Portland-Oregon City superhighway. The action was taken as the result of the unusually large number of pedestrian deaths at the intersections on this highway.

Prison Labor on reconstruction and maintenance of state and county roads in Maryland is authorized in a bill passed by the general assembly of that state as a part of a program being worked out to provide employment for the prisoners. The state's road commission is given power to spend $109,000 in 1938 and the same amount in 1939 to carry out the plan.

An Engineer Registration board has been appointed in Nebraska in accordance with provisions of an act recently passed by the legislature (*ENR*, April 8, 1937, page 536). The members of the board are A. L. Turner, Omaha engineer; Charles Steinbaugh, Omaha architect; D. L. Erickson, Lincoln engineer; W. L. Steele, Omaha architect; Roy M. Green, Lincoln engineer.

Canalization of the San Antonio River from the Gulf to San Antonio, a distance of about 150 miles, is proposed in a bill which has been passed by the Texas legislature. The original scope of the measure was considerably curtailed before its final passage, but the act is expected to serve as the basis for preliminary steps in the project. It creates the San Antonio River Canal and Conservation District which is authorized to lay the plans for the proposed canal before the federal government and to have surveys made to determine the feasibility and probable cost of the project.

Sodium Lights are to be installed on the new Pattulo Bridge across the Fraser River at New Westminster, twelve miles east of Vancouver, B. C., Canada. The sodium installation, which is the first of its kind in Canada, will be installed and maintained by the provincial government. Sixty-two 10,000-lumen sodium lamps will be put in operation when the bridge is opened in September. They will be controlled by photoelectric equipment. Spaced at an average distance apart of 116 ft., the lights will be staggered along the bridge and mounted 25 ft. above the pavement on ornamental standards.

Changes in tidal currents in San Francisco Bay expected to result from the creation of an artificial island northward of Yerba Buena as a site of the 1939 San Francisco World's Fair will be studied as the result of a co-operative arrangement between the U. S. Coast and Geodetic Survey and the Corps of Engineers. Observations will be taken at half-hourly intervals at three points near the island, and it is hoped also to procure readings in the vicinity of the two new bridges. The results of the study will be used to revise current charts and tables covering the locality and used generally by mariners.

To Combat hazardous conditions arising from the recent flood, the city council of Portsmouth, Ohio, has passed an ordinance providing for the condemnation and destruction of dangerous buildings. It provides that whenever the health department finds any building unfit for occupation because of unsanitary conditions it shall order it vacated immediately under penalty of fine or imprisonment. It is further provided that whenever the fire department finds any building to be a fire hazard it shall order it condemned and removed. On the order of condemnation the property shall be vacated and must not be reoccupied until it has been repaired or rebuilt in compliance with provisions of the ordinance.

Wiley Is Engineer Head At Purdue University

The name of Prof. Ralph B. Wiley, whose appointment as head of the School of Civil Engineering and director of the Materials Testing Laboratory at Purdue University was noted in these pages last week, was incorrectly given as Ralph B. Wylie.

Prof. Wiley's appointment becomes effective at the end of the present academic year upon the retirement of Dr. W. K. Hatt.

High Water in New England Halts Bridge Building

A forty-eight hour rain that brought New England streams to flood stage over the week-end halted extensive bridge building operations in the Connecticut and Merrimack River valleys, where work is underway in replacing structures washed out in the record flood of a year ago. Projects affected were at Lowell, Mass., and Manchester, N. H., on the Merrimack, and at Chesterfield, Lebanon, Lyme and Orford, N. H., on the Connecticut. High water in Maine streams stopped bridge work a week ago.

The only damage occurred at Chesterfield, where the west half of a temporary bridge built on the site of the famous old Brattleboro suspension bridge went out. Consisting of steel girders on timber tower bents, the bridge was about 300 ft. long and was built a year ago to carry traffic until a 425-ft. span steel arch just upstream could be built. The bents which went out were about 60 ft. high and founded on ledge rock to which the piles were doweled. One panel of the steel arch had been erected on falsework last week and the steel piles, which had been cut into the ledge by equipping them with knife shoes, held tight. The temporary bridge had survived the spring ice by being loaded with earth on its deck, but its hold on the ledge may have been weakened so that the high velocity of the present flood pushed it off. Decision on rebuilding the bridge has not been reached. It is reported that other temporary bridges on the Connecticut were not damaged.

Personals

Virgil B. Buckley of Little Rock, Ark., has been named engineer in charge of the work of the Pulaski County, Ark., planning commission.

Capt. Wm. G. DuBose has been appointed chief constructor and chief of the Bureau of Construction and Repair, U. S. Navy, to relieve Rear Admiral Emory S. Land who retired Mar. 15.

H. F. Faulkner, for 28 years a member of the Seattle, Wash. city engineering staff, has transferred to the engineering staff of Seattle City Light to serve as engineer in charge of concrete control on the $5,000,000 Ruby Dam project.

L. S. Vance has been appointed chief engineer of the Louisville, Ky. Water Co., filling the office made vacant by the death of Dan Chambers. Mr. Vance has been connected with the Louisville Water Co. since his graduation from Cornell.

R. E. Beith of Toronto has been appointed senior assistant engineer in the St. John N. B. branch of the Canadian department of public works. Mr. Beith had been in Toronto for some years in civil service work for the provincial and dominion governments.

Harry A. Thomsen, Jr., has announced that he will continue the architectural practice of the late George W. Kelham of San Francisco, Calif., with whom Mr. Thomsen was associated for some years. Associated with Mr. Thomsen will be William G. Pigeon and J. F. Beuttler.

Col. James A. O'Connor, C. of E., U. S. district engineer at Buffalo, N. Y., since 1933, will be transferred to the Fifth Engineers at Ft. Belvoir, Va. on Aug. 10. He will be succeeded at Buffalo by Lt.-Col. Edwin H. Marks, C. of E., now district engineer at Galveston, Tex.

Cleves H. Howell, Jr., has been appointed junior engineer for the Bureau of Reclamation on the Rio Grande investigation at Pogosha Springs, Colo. Mr. Howell has been serving as junior hydraulic engineer in the field service of the Geological Survey.

Seth G. Hess has been appointed chief engineer of the Inter-state Sanitation Commission (New York-New Jersey) with headquarters at New York. At the time of his appointment, Mr. Hess was with the PWA state engineer for New York State, and he was formerly with Alexander Potter, consulting engineer.

George J. Trinkhaus has associated himself with the Chicago consulting firm of Marr, Green & Opper. As a result of the death of Paul E. Green, a change in officers has taken in place; G. L. Opper becoming president; J. G. Green, vice-president; and Charles W. Green, secretary-treasurer.

Oliver W. Gatchell, for the past three years electrical engineer and chief of the public utility section of the Muskingum flood control project in the U. S. Engineer Office, at Zanesville, Ohio, has been appointed chief engineer of the Rural Electrification Division, Copper Wire Engineering Association.

Obituary

W. H. WHEELER, a contractor who had installed municipal waterworks in Wisconsin, Iowa, and Illinois, died May 6 in Beloit, Wisc. at the age of 90.

PATRICK W. GRAHAM, 65, general contractor and former superintendent of sewers in Cleveland, died recently in Cleveland. Mr. Graham's firm is now executing a sewer contract in Buffalo.

ARTHUR NOSWORTHY, head of the Eastern Contracting Co. and the Nosworthy Contracting Co., of New York and Brooklyn, died in Freeport, L. I., May 10 at the age of 66.

GEORGE L. PRATT, for 30 years before his retirement in 1927 a member of the engineering department of the Boston & Maine Railroad, died at Reading, Mass., May 5 at the age of 74.

FRANKLIN C. PILLSBURY, project engineer in the Massachusetts department of public works, with which department he had been associated for more than 40 years, died May 15 in Brookline, Mass., at the age of 67. Before entering the department of public works, Mr. Pillsbury was associated for nine years with Ernest W. Bowditch of Boston.

EDWARD F. MCCALL, 51, senior civil engineer in the Dallas, Texas, department of public works, died there May 6. Mr. McCall graduated in 1907 from the University of Texas and later took post graduate work at Cornell University. He joined the Dallas engineering staff in 1910 and had been associated with that department since that time.

ROBERT HOOKE, who retired in 1928 after 38 years of service as city engineer of Chattanooga, Tenn., died May 11 in that city at the age of 84. Mr. Hooke helped to lay out the city of Birmingham and had been engineer in the construction of Muscle Shoals canal.

KENNETH SHIBLEY, 55, an engineer of Seattle, Wash., and founder of the Shibley Co., died May 15. Mr. Shibley served from 1905 to 1921 with the U. S. Reclamation Service, being connected with the work on Roosevelt dam and the Grand Canal in Salt River valley, Arizona. He was connected at various times with the Kierulff Co., of Los Angeles and the California Jewell Filter Co.

WALTER McI. WOLF, 49, Baltimore civil engineer and vice-president of the Northeastern Construction Co., died in Baltimore May 11. Mr. Wolf was a graduate in civil engineering of the Virginia Military Institute. He served as a captain in the Sixth Engineers during the World War and was principal assistant engineer with Frederick L. Cranford on construction of part of the dual subway system in New York City.

H. GASSAWAY BROWN, JR., 36, engineer of the New Rochelle Water Co., died May 6 in New Rochelle, N. Y. Mr. Brown had been associated with the water company since 1927 and for three years previously had been employed by the Public Service Production Co., East Orange, N. J. during the construction of the Kearney power station. He was a graduate in 1922 of the College of Engineering, Cornell University.

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LARGER AWARDS FOR THE WEEK

Turbo-generator and steam condenser for power plant, Long Island Lighting Company, Glenwood Landing, N. Y	$2,000,000
Plant, North American Rayon Corporation, New York City, in Elizabethton, Tenn.	2,500,000
Excavating, grading, foundations and sewers for wide strip mill, Carnegie-Illinois Steel Company, Clairton, Pa. Total estimate	20,000,000
Apartments, two 12-story, Walford Estates, Inc. at 3 East 69th and 4 East 70th Streets, New York, N. Y.	800,000
Store building, W. C. Stripling Company, Fort Worth, Tex	500,000
Highways, Montana	500,000
Highways, Nevada	539,000
Bridge and approaches over Connecticut River between Gill and Montague, Mass.	860,000
South High Street-East Miller Avenue Viaduct, Akron, O	662,000
North Loup River Public Power and Irrigation District, diversion dams for power and irrigation project, and other appurtenant work, Erd, Nebr.	651,000
Flood control improvements, Los Angeles County, Los Angeles, Calif	800,000

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
May, 1937	232.65	111.85	Apr., 1937	161	71
Apr., 1937	230.25	110.64	Mar., 1937	147	64
May, 1936	203.40	97.77	Apr., 1936	166	73
1936 (Av.)	206.46	99.24	1936 (Av.)	185	81
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50

CONTRACTS
(Thousands of Dollars)

	Weekly Average May 1936	Weekly Average Prev. 4 Weeks	Week May 20 1937
Fed. Government	$3,008	$2,977	$2,361
State and Municipal	22,797	23,962	14,266
Total public	$25,805	$26,939	$16,627
Total private..N	9,509	24,742	38,617
Week's total	**$35,314**	**$51,681**	**$55,244**

Cumulative to date:
1936 (21 weeks) $901,992,000
1937 (20 weeks) $913,413,000

Note: *Engineering News-Record* reports waterworks and earthwork, reclamation or waterways projects of $15,000 and over in size; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000 and over. The figures above represent the volume of contracts and large force account projects throughout the U. S. that are of these minimum sizes or over.

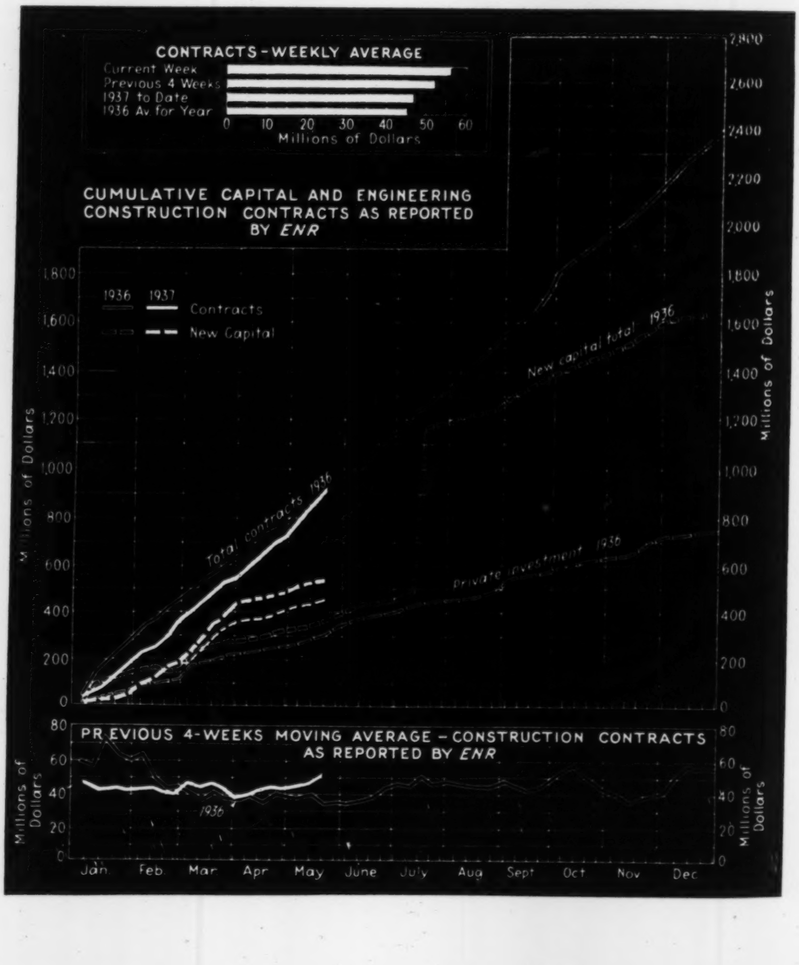
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

1937	Week May 20	Cumulative
Private investment	$19,775	$461,684†
State and municipal bonds	6,902	219,145†
Corporate securities	12,873	242,539
Federal financing	$57	$78,574†
PWA non-federal Projects	57	48,642†
R.F.C. Loan	....	29,932
Total non-federal	$19,832	$540,258
Federal projects	....	....
Total	$19,832	$540,258

Cumulative to date:
1936 (21 weeks) $367,968,000
1937 (20 weeks) $540,258,000

Note: These figures include private bonds and stocks sold for new construction purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

† Includes transfer from federal to private investment financing through sale by RFC of PWA bonds.



CONTRACTS-WEEKLY AVERAGE

CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY *ENR*

PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY *ENR*

Current Construction Unit Prices

Gene Wash and Copper Basin Dams

Owner:
Metropolitan Water District of Southern California; F. E. Weymouth, Gen. Mgr. and Chief Engineer.

Project:
Two high concrete dams at east end Colorado River Aqueduct near Parker Dam. Schedule 1—Gene Wash Dam: Thin concrete arch 156 ft. max. height, crest 315 ft. long, joining gravity section one end 115 ft. long; detached concrete spillway 460 ft. weir; separate earth dikes 25 ft. max. height, total length 1,300 ft. faced with reinf. concrete. Schedule 2—Copper Basin Dam: Thin concrete arch 210 ft. max. height, crest 220 ft. long; detached concrete spillway; reservoir outlet structure. See sketches for plan and sections of dams.

Conditions:
Both sites accessible by road. Prevailing rates must be paid, stipulated as $3.80 per day (8 hr.) for laborers up to $9.00 for shovel operators. Contract time limit Sept. 30, 1938. From May 1 to Oct. 31 concrete may be placed only at night. Cooling coils of 1-in. tubing embedded in concrete dams.

Bids:
Opened Mar. 18, 1937. Ten proposals submitted for each schedule: range for both schedules $594,207 to $859,833. Contract awarded low bidder (same contractor) on both schedules.

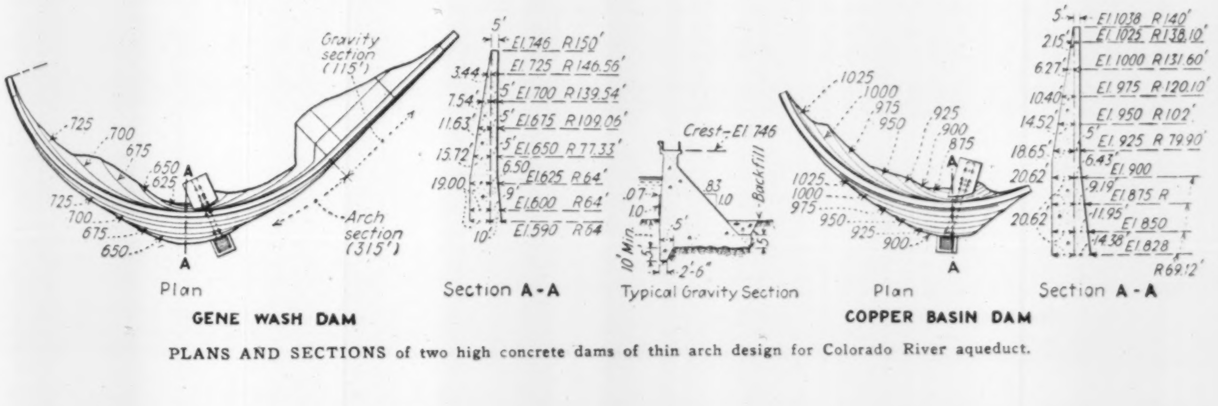
Materials Furnished:
District furnishes f.o.b. Earp, Calif., all permanent materials such as cement, pipe, steel and reinforcing bars, gates, operating mechanism, electrical conduits, grout pipe and fittings, paint, etc.

Low Bidders:

1. J. F. Shea Co., Inc., Los Angeles (both contracts).	Sched. 1	$284,062
	Sched. 2	310,145
2. Metropolitan Const. Co., Los Angeles.	Sched. 1	319,795
	Sched. 2	311,805
3. Utah Const. Co., San Francisco.	Sched. 1	316,163
	Sched. 2	320,710

GENE WASH AND COPPER BASIN DAMS, COLORADO RIVER AQUEDUCT

	Gene Wash Dam				Copper Basin Dam			
		Unit Prices				Unit Prices		
Item	Quan.	(1)	(2)	(3)	Quan.	(1)	(2)	(3)
1. Excav., unclass., dam fdns	6,500 c. y.	$3.50	$8.00	$5.00	5,500 c. y.	$3.50	$8.00	$4.30
2. Excav., unclass., spillways, etc	11,000 c. y.	3.50	2.00	2.30	4,500 c. y.	3.50	2.00	2.00
3. Excav., unclass., res. outlet	......	......	......	......	1,000 c. y.	6.00	2.00	2.00
4. Excav., unclass., for earth dikes	4,000 c. y.	.25	.50	.50	......	......	......	......
5. Excav., unclass., dike cutoff wall	600 c. y.	5.00	3.00	2.30	......	......	......	......
6. Earth fill in dikes	10,500 c. y.	.50	.50	.50	......	......	......	......
7. Backfill	1,500 c. y.	.50	.50	.25	4,500 c. y.	1.00	.50	.25
8. Compacted backfill	50 c. y.	1.00	1.00	.60	1,500 c. y.	1.50	.60	.60
9. Drill grout holes, 0-25 ft	5,000 l. f.	1.00	1.00	1.20	4,500 l. f.	1.00	1.00	1.20
10. Drill grout holes, 25-50 ft	1,000 l. f.	2.50	2.00	1.80	1,300 l. f.	2.50	2.00	1.80
11. Drill grout holes, 50-100 ft	375 l. f.	3.00	4.00	2.30	375 l. f.	3.00	4.00	2.30
12. Install grout pipes, fdns	13,000 lb.	.10	.10	.07	12,000 lb.	.10	.10	.07
13. Install grout pipes, dam joints	4,000 lb.	.10	.10	.07	4,500 lb.	.10	.10	.07
14. Install cooling system tubing	21,000 lb.	.10	.10	.09	20,000 lb.	.10	.10	.09
15. Furnish and oper. cooling plant	Lump sum	15,000.00	8,000.00	14,000.00	Lump sum	15,000.00	8,000.00	14,000.00
16. Pressure grouting, fdns	6,500 c. f.	1.50	1.50	1.50	6,100 c. f.	1.50	1.50	1.50
17. Pressure grouting, dam joints	225 c. f.	1.50	2.00	1.70	210 c. f.	1.50	2.00	1.70
18. Concrete in dam	13,000 c. y.	7.00	10.00	9.80	14,000 c. y.	7.00	10.00	9.80
19. Concrete in spillway	3,200 c. y.	7.50	10.00	9.20	450 c. y.	8.50	10.00	9.20
20. Concrete paving on dike	500 c. y.	7.50	10.00	11.50	......	......	......	......
21. Concrete, dike cutoff	700 c. y.	7.50	10.00	7.00	......	......	......	......
22. Concrete, reservoir outlet	......	......	......	......	2,215 c. y.	25.00	16.00	20.70
23. Concrete, trash rack structure	20 c. y.	30.00	25.00	28.00	25 c. y.	25.00	25.00	28.00
24. Concrete, valve house	160 c. y.	25.00	15.00	34.00	190 c. y.	25.00	15.00	34.00
25. Concrete, parapet	110 c. y.	30.00	25.00	28.00	60 c. y.	30.00	25.00	28.00
26. Gatehouse superstructure	......	......	......	......	Lump sum	11,000.00	6,000.00	4,700.00
27. Gunite	75 c. y.	50.00	30.00	23.00	40 c. y.	50.00	25.00	23.00
28. Place reinf. steel	537,000 lb.	.025	.02	.014	500,000 lb.	.025	.02	.014
29. Install metal sealing strips	35,000 lb.	.15	.03	.20	25,000 lb.	.10	.03	.20
30. Install sluiceway pipe	20,000 lb.	.025	.03	.04	40,000 lb.	.025	.03	.04
31. Install trash racks, outlet	......	......	......	......	50,000 lb.	.025	.03	.04
32. Install trash racks, sluiceway	30,000 lb.	.025	.03	.04	45,000 lb.	.025	.03	.04
33. Install sluiceway gate	25,000 lb.	.025	.03	.04	40,000 lb.	.025	.03	.04
34. Install slide gates	......	......	......	......	150,000 lb.	.03	.03	.03
35. Install discharge valve	25,000 lb.	.03	.03	.04	30,000 lb.	.03	.03	.04
36. Install misc. metal work	15,000 lb.	.10	.03	.08	50,000 lb.	.10	.03	.08
37. Install pipe railing	11,000 lb.	.10	.03	.08	6,000 lb.	.10	.03	.08
38. Install elec. conduit and boxes	......	......	......	......	1,800 lb.	.10	.30	.20
39. Haul steel	7,500 t. m.	.10	.05	.08	6,000 t. m.	.10	.05	.08
40. Haul cement	92,000 t. m.	.10	.05	.08	60,000 t. m.	.10	.05	.08
41. Clear reservoir site	Lump sum	5,750.00	3,000.00	6,600.00	Lump sum	10,875.00	5,000.00	12,500.00



PLANS AND SECTIONS of two high concrete dams of thin arch design for Colorado River aqueduct.

Oil Processed Road, Arizona

Owner:
Arizona State Highway Department.

Project:
Grading, drainage, aggregate base course, oil processing and incidental work on 2 mi. Tucson-Florence highway adjacent to Tucson.

Bids:
Received Apr. 6, 1937; contract awarded same day to low bidder. Ten proposals submitted; range $162,778 to $199,479.

Conditions:
Federal aid project. Completion date Dec. 15, 1937.

Low Bidders:

1. Tanner Const. Co., Phoenix (contract)	$162,778
2. Lee Moor Contr. Co., El Paso, Tex.	166,894
3. Pearson & Dickerson, Tempe, Ariz.	169,170

Item	Quan.	UNIT PRICES (1)	(2)	(3)
1. Roadway excav., unclass	23,246 c. y.	$0.40	$0.26	$0.40
2. Drainage excav., unclass	1,472 c. y.	.40	.26	.40
3. Struc. excav., unclass	1,223 c. y.	1.10	1.00	1.50
4. Remove old concrete	10 c. y.	10.00	6.00	18.00
5. Station-yard overhaul	2,478 st. y.	.02	.03	.015
6. Cubic-yard mile haul	641 cy. m.	.25	.40	.36
7. Imported borrow	10,536 c. y.	.18	.17	.20
8. Imported borrow haul	19,032 cy. m.	.12	.14	.15
9. Coarse aggregate base course	13,130 tons	.65	.70	.75
10. Fine aggregate base course	1,159 tons	.75	.90	.90
11. Sprinkling	1,076 M. g.	1.25	.75	1.20
12. Rolling	375 hr.	2.00	3.00	3.00
13. Conc. pave., driveways	1,479 s. y.	2.20	3.00	3.00
14. Concrete, Cl. A, incl. cement	578 c. y.	18.00	18.30	19.00
15. Reinforcing bars	54,733 lb.	.05	.049	.048
16. Cement rubble ditch lining	2,350 s. y.	1.20	1.50	1.25
17. Rebuild fence	3,317 l. f.	.10	.05	.125
18. Standard steel gates	1 each	25.00	20.00	18.00
19. Right-of-way markers	18 each	4.00	3.00	4.00
20. Spec. comb. curb and gutter	7,746 l. f.	.95	1.00	1.00
21. Spec. comb. curb and gutter	220 l. f.	1.02	1.20	1.25
22. Spec. integral curb and gutter	11,571 l. f.	2.17	2.45	2.10
23. Spec. integral curb and gutter	560 l. f.	2.24	2.75	2.50
24. Single curb, Type E	16,174 l. f.	1.05	1.00	.90
25. Valley gutter	2,452 l. f.	1.25	1.20	1.05
26. Curb and gutter transition	80 each	22.00	25.00	25.00
27. Concrete sidewalk, 4 in	69,290 s. f.	.17	.20	.16
28. Corr. metal pipe, 30 in	372 l. f.	3.50	3.30	3.00
29. 12-in pl. conc. pipe under road	442 l. f.	1.30	1.30	1.62
30. 18-in. pl. conc. pipe under road	248 l. f.	2.10	2.25	2.28
31. 24-in. pl. conc. pipe under road	256 l. f.	4.25	4.70	4.80
32. 12-in. pl. conc. pipe not under road	300 l. f.	1.30	1.30	1.62
33. 18-in. pl. conc. pipe not under road	752 l. f.	2.10	2.25	2.28
34. 24-in. pl. conc. pipe not under road	256 l. f.	3.10	3.50	3.30
35. Double conc. catch basins	8 each	50.00	45.00	60.00
36. Conc. catch basins No. 2	12 each	50.00	33.00	60.00
37. Std. irrigation standpipes No. 2	1 each	60.00	45.00	60.00
38. Plant mix, not incl. asphalt	10,507 tons	2.08	1.75	2.00
39. Plant mix seal coat, not incl. asph	1,030 tons	4.00	3.60	4.50
40. Cutback asphalt for plant mix	482 tons	23.50	23.00	25.20
41. Remove 6-in. conc. pave	14,886 s. y.	.20	.40	.36
42. Remove 4-in. concrete base	1,840 s. y.	.20	.35	.30
43. Remove 2-in. asph. surface	1,840 s. y.	.08	.25	.24
44. Remove oil mix	1,839 s. y.	.05	.25	.10
45. Remove single curb	100 l. f.	.25	.25	.12
46. Remove misc. conc., trees, hedges	Lump sum	500.00	225.00	1,450.00

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Highway Seal Coat, Arizona

Owner:
Arizona State Highway Department.

Project:
Seal coating 18 mi. of existing oil surface between Coolidge and Pichacho on Florence-Tucson highway; non-federal aid.

Bids:
Opened Apr. 2, 1937. Five proposals submitted; range $16,800 to $20,500. Contract awarded low bidder.

Conditions:
Completion time 30 days after award of contract.

Low Bidders:

1. Reliance Trucking Co., Phoenix (contract)	$16,880
2. Arizona Sand & Rock Co., Phoenix	17,499
3. Pearson & Dickerson Contractors Inc., Tempe, Ariz.	17,920

Item	Quan.	UNIT PRICES (1)	(2)	(3)
1. Emulsified asphalt, Cl. A	350 tons	$24.00	$26.74	$27.20
2. Screenings	2,000 tons	4.24	4.07	4.20

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River St. Viaduct, Tacoma

Owner:
State Highway Department, Washington; L. V. Murrow, director of highways.

Project:
River St. viaduct, steel and reinforced-concrete structure 2,400 ft. long, with approaches: total length 0.634 mi.

Conditions:
PWA grade crossing project; PWA labor rates and regulations apply. Completion time, 270 calendar days.

Bids:
Opened Mar. 30, 1937, at Olympia, Wash. Ten bids submitted, range from $239,404 to $309,304. Contract awarded low bidder.

Low Bidders:

1. Rumsey & Co., Seattle, Wash. (contract)	$239,404
2. C. L. Creelman, Seattle	254,423
3. Teufel & Carlson, Seattle	263,148

Item	Quan.	UNIT PRICES (1)	(2)	(3)
Approaches:				
1. Clearing and grubbing	Lump sum	$1,000.00	$2,200.00	$500.00
2. Excav., unclass	890 c. y.	.50	.60	.50
3. Excav., struct	50 c. y.	2.00	1.00	1.00
4. Excav., class D	10 c.y	1.00	2.50	1.00
5. Finishing roadway	34 sta.	10.00	9.00	10.00
6. Select roadway borrow	7,380 c. y.	.50	.70	.65
7. Crushed stone top course	160 c. y.	2.50	3.00	2.50
8. Crushed stone base course	240 c. y.	2.50	2.50	2.50
9. Filler	60 c. y.	1.00	1.00	1.00
10. Water on roadway	15 M gal.	5.00	4.00	5.00
11. Type I asph. conc. pave., Cl. C wearing course	50 tons	10.00	11.00	10.00
12. Type I asph. conc. pave., Cl. F leveling course	140 tons	10.00	11.00	10.00
13. Type I asph. conc. pave., Cl. G leveling course	20 tons	10.00	11.00	10.00
14. Cement concrete pavement	1,655 s. y.	2.25	2.30	2.25
15. Cem. concrete pavement, high early strength	1,270 s. y.	2.50	2.50	2.45
16. Cem. concrete pavement, std.	44 c. y.	15.00	13.00	15.00
17. Concrete base, h. e. s	26 c. y.	16.00	14.00	16.00
18. Pavement header No. 3	60 l. f.	.75	.90	.75
19. Pavement header No. 4	360 l. f.	1.00	1.00	1.00
20. Dowel bars with caps	560 each	.25	.25	.20
21. Dowel bars without caps	1,220 each	.20	.20	.16
22. Pave. reinforcing Type 2	21,270 lb.	.05	.05	.06
23. Steel reinforcing bars	2,260 lb.	.05	.052	.07
24. Integral concrete curb	56 l. f.	.75	.70	.75
25. High conc. curb, special design	548 l. f.	.75	1.00	1.15
26. Special conc. curb	6 c. y	30.00	25.00	16.00
27. Sidewalk, 4 in. concrete	140 s. y.	1.50	1.50	1.75
28. Reinf. concrete marker	2 each	10.00	15.00	10.00
29. Precast conc. slab R.R. crossing	Lump sum	1,000.00	1,000.00	1,000.00
30. Guard rail Type 3	534 l. f.	.50	.70	.90
31. Special catch basin, des. A	2 each	125.00	90.00	85.00
32. Treated timber track ties	700 each	2.50	2.30	2.25
33. Remove existing pave	1,654 s. y.	.40	.60	.50
34. Remove existing granite curb	210 l. f.	.50	.30	.20
35. Sewer pipe, 6-in., conc. or v. t	80 l. f.	.50	1.00	.40
36. Sewer pipe, 18-in., concrete	45 l. f.	3.00	3.00	2.25
Viaduct Structure:				
37. Excavation, struc	1,200 c. y.	2.00	2.00	5.00
38. Concrete, Cl. A	2,180 c. y.	18.00	20.00	18.00
39. Concrete, Cl. B	575 c. y.	18.00	20.00	24.00
40. Steel reinf. bars	536.000 lb.	.05	.05	.06
41. Structural silicon steel	348.000 lb.	.08	087	.085
42. Structural carbon steel	377.000 lb.	.075	078	.075
43. Copper seals	140 lb.	.70	.60	1.00
44. Cast steel drains	56 each	25.00	20.00	40.00
45. Creosoted timber and lumber	380 M. b. m.	75.00	77.00	86.00
46. Zinc. chl. treat. timber	12 M. b. m.	65.00	64.00	80.00
47. Furnish treated timber piles	31,500 l. f.	.60	.60	.65
48. Furnish plain timber piles	9,000 l. f.	.20	.17	.20
49. Drive treated timber piles	514 each	10.00	9.00	9.00
50. Drive plain timber piles	224 each	10.00	10.00	10.00
51. Reinf. conc. bridge rail	4,244 l. f.	2.00	3.00	2.50
52. Pipe handrail Type 1	404 l. f.	2.50	2.80	2.50
53. Pipe handrail Type 2	160 l. f.	5.00	2.50	4.00
54. Steel drain pipe, 4 in	330 l. f.	2.00	1.00	2.50
55. Conduit for lighting system	Lump sum	2,000.00	1,600.00	2,000.00
56. Furnish and drive test piles	6 each	50.00	70.00	75.00
57. Remove existing struct	Lump sum	5,000.00	4,000.00	5,000.00
58. Remove existing conc. footings	Lump sum	2,000.00	2,000.00	2,000.00
59. Asbestos blast plates	Lump sum	350.00	900.00	500.00
60. Conduit for fire alarm	Lump sum	700.00	800.00	700.00
61. Remove old fdn. piles (force-acct.)	Est.	500.00	500.00	500.00